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PROCEEDINGS OF THE THIRTY-FIRST ANNUAL MEETING OF THE NORTH CAROLINA ACADEMY OF SCIENCE

WAKE FOREST COLLEGE, WAKE FOREST, N. C., MAY 6 AND 7, 1932

The thirty-first annual meeting of the North Carolina Academy of Science was held at Wake Forest College, May 6 and 7, 1932. The meeting was called to order at 9:30 A.M. on May 6, by the president, Dr. F. A. Wolf. The reading of papers was begun and continued until 12:50 P.M., when the president appointed the following committees:

Auditing: B. B. Fulton, Ruth N. Addoms, Earl H. Hall.

Nominating: W. L. Poteat, W. F. Prouty, H. B. Arbuckle.

Resolutions: J. P. Givler, Ella M. Martin, I. V. Shunk.

The Academy then took a recess for a pichic lunch served on the college campus by the ladies of Wake Forest.

The reading of papers was resumed at 2:15 P.M. and continued until 4:30 P.M., when the Academy went into business session.

The minutes of the previous meeting were approved as published in the *Journal of the Elisha Mitchell Scientific Society*.

Reports were called for from the various committees.

The executive committee, consisting of F. A. Wolf, president of the Academy; W. E. Speas, vice-president; H. R. Totten, secretary and treasurer; Bert Cunningham, W. L. Porter, and F. W. Sherwood reported as follows:

"The executive committee met at Durham on May 5 and again at Wake Forest on May 6, with all of its members present.

"The committee passed favorably upon the following changes and additions to the program: A shift in the position of the paper by J. O.

Halverson from that given on the printed program; the addition to the program of a paper by W. C. Coker entitled 'A New Species of *Bignonia*'; the substitution by W. C. Coker and H. R. Totten of a joint paper entitled 'Extended Ranges of Plants in North Carolina' for the one on fungi in the printed program; the addition of an exhibit by Bert Cunningham entitled 'Does a Snake have Legs?'

"The committee reported as elected to membership since the last annual meeting the following:

Abell, Charles A., Junior Forester, U. S. Forest Service, Appalachian Forestry Experiment Station, Asheville, N. C.

Abell, Mrs. Margaret Stoughton (Margaret Stoughton, at time of election), Junior Forester, U. S. Forest Service, Appalachian Forestry Experiment Station, Asheville, N. C.

Alexander, James A., Teaching Fellow in Geology, University of North Carolina.

Anderson, Lewis Edward, Assistant in Botany, Duke University.

Baroody, B. J., Student in Biology, Duke University.

Byerly, Kenneth, Assistant in Geology, University of North Carolina.

Carroll, J. G., Associate Professor of Mathematics, Wake Forest College.

Causey, Rebecca, Student in Biology, North Carolina College.

Craven, C. J., Instructor in Physics, University of North Carolina.

Douglas, John G., Associate Professor of Geology, University of North Carolina.

Githens, Sherwood, Jr., Teaching Fellow in Physics, University of North Carolina.

Graham, Minnie A., Professor of Physical Science, Queens-Chicora College.

Green, Esther, Graduate Student in Geology, University of North Carolina.

Griffin, Mabel, Student in Mathematics, Duke University.

Harmon, Fannie, Associate Professor of Biology, Catawba College.

Harvey, Harlow W., Jr., Graduate Assistant in Botany, Duke University.

Ingersoll, Louise M., Practicing Physician, Asheville, North Carolina.

Johnson, Frank H., Graduate Student in Botany, Duke University.

Jones, Hubert A., Professor of Mathematics, Wake Forest College.

Jones, Ivan D., Associate Professor of Horticulture, State College.

Koehring, Vera, Associate Biologist, U. S. Fisheries Laboratory, Beaufort, N. C.

Kramer, Paul J., Instructor in Botany, Duke University.

Latham, D. H., Graduate Assistant in Botany, Duke University.

Lear, C. Merritt, Graduate Student in Physics, University of North Carolina.

Lieneman, Catherine, Instructor in Biology, North Carolina College.

Mann, H. B., Agronomist, State College.

Morehead, Robert Page, Graduate Student in Biology, Wake Forest College.

Nelson, Ralph M., Assistant Pathologist, Appalachian Forestry Experiment Station, Asheville, North Carolina.

Prytherch, Herbert F., Director of U. S. Fisheries Laboratory, Beaufort, N. C.

Pyron, Joseph H., Fellow in Botany, Duke University.
Scholz, Ruth, Student in Biology, North Carolina College.
Sims, I. H., Assistant Silviculturist, U. S. Forest Service, Appalachian Forestry Experiment Station, Asheville, N. C.
Taylor, Otis B., Assistant Professor of Zoology, State College.
Thiel, Albert F., Professor of Biology, North Carolina College.
Vardell, Mary Linda, Graduate Student in Botany, University of North Carolina.
Williams, M. A., Graduate Student in Chemistry, Wake Forest College.

Lost by death:
Ashe, W. W., Senior Forest Inspector in "Region 7" (Eastern United States) U. S. Forestry Service, Washington, D. C.
Seymour, Mary Frances, Professor of Biology, Catawba College.

Lost by resignation:
Dashiell, J. F.
Goodwin, H. S.
Jones, E. P.
Lothery, T. E., Jr.
Mourane, J. H.
Murray, V. F.
Vilbrandt, F. C.
Wood, W. W.
Wright, E. Katherine.

Lost after removal from the state:
Anderson, W. A.
Bush, L. E.
Callahan, Dixon
Davis, J. H.
Fant, G. W.
Jenkins, W. E.
Kaston, B. J.
Raper, K. B.
Schallert, Dorothea A.
Schomer, Harold A.
Terrill, Elizabeth D.
Yocum, L. E.

Dropped from the roll for non-payment of dues: Twenty-seven former members.

"The executive committee has been approached as to the advisability of holding a joint meeting of the southeastern academies in 1933. The committee has replied that it favors such a meeting provided it does not take the place of our regular annual meeting.

"The committee accepted the invitation from Davidson College to hold the thirty-second annual meeting in Davidson.

"The executive committee made the following recommendations to the Academy:

1. "That all bills presented in the Treasurer's report be authorized and paid and that the report be printed when audited.

2. "That H. B. Arbuckle be appointed a committee of one to select the cup to be given to the winner of the high school science essay prize, and that he be authorized to draw upon the treasury for as much as $25.00 for the cup; and that the Academy send a representative to the commencement of the Greensboro High School to deliver this Academy prize and that the Secretary of the Academy be authorized to select the Academy representative and to pay the expenses of his trip from the Academy funds.

3. "That By-Laws 3 and 5 be revised so as to make the Academy year agree with the calendar year. That By-Law 3 be revised to read: 'All elections to membership shall apply to the current *calendar year*, and no annual fee shall be collected for the year of such election.' That By-Law 5 be revised to read: 'Yearly dues regularly become payable on January 1st, of each year.'

4. "That the Academy having completed thirty years of service to North Carolina hereby show its appreciation of its charter members by electing those now on our roll to *life membership*. These men are: C. S. Brimley, H. H. Brimley, W. L. Poteat, Franklin Sherman, Jr., and H. V. Wilson.

5. "That the Academy elect to *life membership* C. W. Stiles, recently retired from the U. S. Public Health Service, who though long out of the state has held his membership in the Academy while laboring so effectively for health improvement throughout the South."

The recommendations of the executive committee were adopted and its report accepted.

The Treasurer's report was as follows:

Financial Statement

1931–1932

Receipts		Expenditures	
Balance on hand, May 3, 1931	$531.81	Stationery, postage, express	$14.81
		Printing, mimeographing, multigraphing, addressographing	53.83
Dues for			
1931	102.00	Journal of the E.M.S.S.	300.00
1932	232.00	Clerical assistance	94.00
		H. S. Essay Prize	25.00

Initiation fees		Dues refund to Sec'y	$2.00
At 1931 meeting	$16.00	Sec'y-Treas. Commis	40.20
Since 1931 meeting	56.00	Lost check refunded to Treas.	2.00
Interest on savings	20.14	Protested checks	2.50
Allotment from A.A.A.S.			$534.34
1931	51.50		
1932	48.50	To balance	530.61
Chemists programs	5.00		$1,064.95
Replacement of lost check	2.00		
	$1,064.95		

Comparison

	1931	1932
Savings account	$496.89	$496.89
Checking account	34.92	21.72
Cash on hand	0.00	12.00
	$531.81	$530.61
To balance (net loss)		1.20
		$531.81

The above report was made as May 4, 1932.

Submitted by

H. R. Totten, *Secretary-Treasurer*

Audited by

B. B. Fulton,

Ruth M. Addoms,

Earl H. Hall.

Date May 6, 1932.

The Treasurer's report was accepted.

The auditing committee reported that they had examined the accounts of the treasurer for the period May 3, 1931, to May 4, 1932, and had found them correct.

The report of the auditing committee was accepted.

The committee on high school science, consisting of Bert Cunningham, chairman; H. B. Arbuckle, Lena Bullard, C. M. Heck, C. E. Preston, and R. N. Wilson reported as follows:

"Your committee reports that it has been carrying on its usual activities, namely: having representatives at the various sectional meetings of the N. C. E. A., supervising the high school prize contest, and considering the improvement of science instruction in the schools.

"In regard to the first matter, the opinion of the committee is that there has been a steady improvement in the science meetings of the various sections; and that at present improvement in these meetings can best be made by more open discussion of current problems by teachers. The committee feels that the effort to create and sustain interest in science should be extended even into the grades. It commends the work of this nature being carried on in certain counties, and hopes that various members of the Academy will respond when invited to coöperate. It also believes that the Academy should give its weight to the program of science for the grades which was initiated a year or so ago by the State Department of Education.

"In regard to the second matter, the committee appointed as judges for the present contest Dr. J. M. Bell, Prof. G. D. Collins, and Dr. J. B. Derieux. The chairman of the Judges made the following report:

Number of contestants, 28. (This included only those papers submitted to the judges. Each school was allowed to submit three of its most worthy papers.)
Number of schools entering, 22.
Winner, Miss Frances Katherine Faust of the Greensboro High School, for an essay entitled 'The Importance of the X-Ray to Humanity."

"In regard to the third point, the chairman of this committee was instructed to get the facts relative to the Certification Department's requirements for the teachers of science. A copy of a letter setting forth the requirements is appended hereto.

Raleigh, N. C.
Nov. 28, 1931.

Dr. Bert Cunningham
Duke University
Durham, N. C.

Dear Doctor Cunningham:

To be issued a High School Certificate one must first of all be a graduate of a four year course. The following subjects represent the general educational requirements common to all High School Certificates:

Educational Psychology	3 S. Hrs.
Principles of High School Teaching or Problems in Secondary Education	3 S. Hrs.
Elective in Education	6 S. Hrs.

For a Class B Certificate in any one subject field one must have credit for 3 semester hours in Materials and Methods in the particular subject, in addition to the 12 hours in Education which I have just outlined above. For the Class A Certificate one must have credit for 3 semester hours in Observation and Directed Teaching, in addition to the course in Materials and Methods.

To satisfy the requirement in Materials and Methods for a certificate to teach Science a 3-hour course in one of four fields of Sciences would be sufficient. The requirement, then, would be met by presenting one of the following courses in Materials and Methods:

Materials and Methods in Teaching Biology	3 S. Hrs.
Materials and Methods in Teaching Chemistry	3 S. Hrs.
Materials and Methods in Teaching Gen. Science	3 S. Hrs.
Materials and Methods in Teaching Physics	3 S. Hrs.

I would prefer that the course in Materials and Methods be taught by a single teacher rather than that it be a combination from a number of teachers. You for example could offer a course in the Materials and Methods of Teaching Biology. That would meet the requirements in Methods for a Science Certificate.

In the content phase of the requirements for a Science Certificate one must have credit for 30 semester hours, including some work in the following subjects:

Biology
Chemistry
Physics
Geography

We do not specify how much credit one shall have in any one of these fields, but simply require a minimum of 30 hours altogether with some credit in each field.

If one wanted a certificate to teach just Biology, then, a total of 30 semester hours in the field of Science with about 24 hours in Biology would meet the requirements. From the point of view of employment a student would be tremendously handicapped if she had a certificate to teach a single Science subject only, instead of a certificate which permits her to teach all Sciences as the regular Science Certificate contemplates.

(Signed)
JAMES E. HILLMAN,
Director of Teacher Training and Certification.

There has been no effort to enter into the requirements of the various institutions as these appear to the committee to be institutional matters, to be corrected, if need be, by faculty action. In the opinion of the committee, the new certification program will produce significant changes in the course work of prospective science teachers.

The committee wishes to make the following recommendations:

1. "That the Academy pledge its support to the State Department of Education in all its efforts to improve and extend science work in public schools. As a partial means to that end, it is suggested that the Academy call to the attention of the State Department of Education (a) that a more careful report of equipment and materials on hand should be demanded—such report to be provided by the science teacher; (b) that the Accrediting Division consider the problem of replacement annually of apparatus and materials, and take steps that will insure such necessary replacement in the several schools. This we consider one of the more important problems.

2. "Your committee recommends that the high school prize be continued, the award in 1933 to be in the fields of biology, botany, zoölogy, or physical geography.

3. "The committee recommends that Dr. H. B. Arbuckle be authorized to purchase the cup as is customary, and that the secretary be authorized to appoint a delegate to present this cup.

4. "The committee recommends that the following qualification be added to the statement relative to the High School Science cup:

"That when any essays are submitted by a school, that school commits itself to provide for the presentation of the cup by a representative of the Academy either at a general assembly of all the high school students or at the commencement exercises of the school.

5. "Your committee recommends that we coöperate, if feasible, with the State Department of Education in sending out at least once a year a "Suggestion Sheet or Pamphlet for Science Teachers," the same to be prepared by a staff (the Secretary of the Academy to be an ex-officio member) appointed by the High School Committee of the Academy. This pamphlet to be filled with short timely suggestions as well as good references to current published material and also to include announcement of the Academy's High School prize. This would replace the present letter announcing the High School prize.

The report of the committee on high school science was accepted.

Dr. J. Henry Highsmith, of the State Department of Education, outlined briefly part of the work of the State Department of Educa-

tion in attempting to improve the science teaching in North Carolina High Schools and pointed out some of the ways in which Academy members could assist in this work and how the State Department could assist in the work of the Academy. Most of these suggestions have been included in the report of the committee on High School Science. Dr. Highsmith further asked that Academy members willing to make science talks to the high schools notify him of the fact.

The general resolutions committee submitted the following report.

I. "The Academy of Science desires to express its regret and loss in the passing of two who have been members of the Academy for many years: Miss Mary Frances Seymour, Professor of Biology at Catawba College, a member of the North Carolina Academy of Science from 1917 to 1922 and later from 1925 until the time of her death on March 2, 1932; and Dr. William Willard Ashe, Senior Forest Inspector in "Region 7" of the U. S. Forest Service, a charter member of the North Carolina Academy of Science, who died March 18, 1932. Special committees have been appointed to prepare suitable memorials to both of these late members of the Academy. For these memorials see pages 40 and 48.

II. "The North Carolina Academy of Science takes this opportunity to express its appreciation of the hospitality extended the Academy at this time by the faculty of Wake Forest College. The beautiful grounds and atmosphere have given to all of us an experience not soon to be forgotten.

III. "The North Carolina Academy of Science in this, its 31st Annual Meeting places itself on record as favoring Senator Fletcher's bill for the creation of the Everglades National Park in Florida.

IV. "The Academy also hereby goes on record as favoring the Agricultural Appropriation Bill, making certain the continuance of necessary scientific research as a function of the Federal Government. It is further our view that the discontinuance of this work would involve severe loss to many classes of citizens and a loss out of all proportion to the nominal saving which would result from bringing it to an end.

It is suggested that these last two resolutions be communicated to our senatorial and congressional representatives at Washington."

J. P. GIVLER, North Carolina College,
ELLA MARTIN, Greensboro College,
I. V. SHUNK, State College.

The above resolutions were adopted.

J. N. Couch, representative of the Academy to the New Orleans meeting of the American Association for the Advancement of Science, gave a report on the meeting of the Academy Conference at this meeting.

The nominating committee submitted the following nominations:

President—J. B. Bullitt, University of North Carolina.

Vice-President—Earl H. Hall, North Carolina College.

New member of the executive committee (for three years)—Charles M. Heck, State College.

A vote was taken and the above nominees were elected.

The attention of the Academy was called to the fact that the North Carolina College Conference has a committee at work studying the question of standardization of college science courses. This involved some discussion and a motion was made that the president appoint a committee to coöperate with representatives of the North Carolina College Conference to study the question of standardization of college science courses. This motion was amended so that the same committee be authorized to represent the Academy at the North Carolina College Conference.

The president appointed to this Committee the following:

Chairman, Bert Cunningham, Professor of Biology at Duke University, P. M. Ginnings, Professor of Chemistry and Physics at Greensboro College, Karl H. Fussler, Professor of Physics at the University of North Carolina, J. B. Bullitt, the new president of the Academy, and H. R. Totten, the secretary of the Academy, members *ex officio*.

The president appointed the following standing committees for the following year:

Legislative Committee: Z. P. Metcalf, State College, chairman, W. L. Poteat, Wake Forest, C. S. Brimley, N. C. Department of Agriculture.

High School Science Committee: Bert Cunningham, Duke, chairman, H. B. Arbuckle, Davidson College, Lena Bullard, Greensboro High School, C. M. Heck, State College, C. E. Preston, University of N. C., R. N. Wilson, Duke.

The business meeting then adjourned.

The Academy reconvened at 8:30 P.M., with Vice-President W. E. Speas presiding. Thurman D. Kitchin, president of Wake Forest College, welcomed the Academy to Wake Forest, Vice-president Speas responded for the Academy and presented President F. A. Wolf who then delivered his presidential address on "An Old Botanical Puzzle" (see abstract on p. 15). His lecture on this puzzle of "Tobacco Frenching" was illustrated with lantern slides.

The Academy convened in sections Saturday morning with President Wolf presiding over the general section; L. A. Bigelow over the chemists, H. D. Crockford, as secretary of the chemistry section; E. T. Browne over the mathematicians, E. R. C. Miles as secretary; J. L. Lake over the physicists, G. D. Collins as secretary in the absence of C. N. Warfield.

The following group officers were elected by the group concerned for the year 1933:

North Carolina Section of the American Chemical Society—Chairman, F. W. Sherwood, N. C. Agricultural Experiment Station; Vice-chairman, H. D. Crockford, University of North Carolina; Secretary-treasurer, R. W. Bost, University of North Carolina; Councilor, L. G. Willis, State College; Executive Committee, L. A. Bigelow, Duke University (three years), A. S. Wheeler, University of N. C. (two years), J. H. Saylor, Duke University (one year).

Mathematics—Chairman, J. M. Thomas, Duke University; Secretary, Helen Barton, North Carolina College.

Physics.—Chairman, H. E. Fulcher, Davidson College; Secretary, C. N. Warfield, North Carolina College.

The following papers were presented before the general section of the Academy. Those marked with * appear in full in this issue; those marked x are abstracted in this issue; for those unmarked no abstract was received; those marked † were presented by title only.

***Causes and Prevention of Corrosion in Gas Mains.* E. E. RANDOLPH and J. M. MORROW, State.

The Nutritive and Feeding Value of Cotton Seed Meal. J. O. HALVERSON, N. C. Agr. Exp. Sta.

x*Effect of Increased Atmospheric Pressure upon the Development of Hen Eggs* (Report of Progress). BERT CUNNINGHAM, Duke.

Notes on the Absorption and Utilization of Nitrogen by the Cranberry Plant. RUTH N. ADDOMS, Duke.

x*Copper Content of Some Foods.* G. H. SATTERFIELD and S. O. JONES, State.

The Movement of Beach Sands. GERALD R. MCCARTHY, U. N. C.

***Some Preliminary Notes on the Ecology of the Upland Communities in the Vicinity of Greensboro.* EARL H. HALL, N. C. C. W.

***Microchemical Studies of the Changes During Vernal Activity in Ginkgo biloba.* RUTH SCHOLZ, N. C. C. W.

Studies of the 6-Nucleate Gametophyte and the Development of the

Embryo in Corallorrhiza odontorhiza (Lantern). REBECCA CAUSEY, N. C. C. W.

The Relation of Fungi to the Nutrition of the Lesser Bulb Fly (Lantern). DON B. CREAGER, Duke.

x*Bluestain Fungi as a Factor in the Death of Southern Pines Attacked by Bark Beetles* (Lantern). RALPH M. NELSON, Appa. For. Exp. Sta.

x*Specific Differences in Basal Wounding by Fire of Southern Appalachian Hardwood Trees* (Lantern). I. H. SIMS, Appa. For. Exp. Sta.

To-day's World-Wide Search for Economic Geologic Deposits (Lantern). COLLIER COBB, U. N. C.

x*Pronunciation of Scientific Words.* GEORGE W. LAY, Chapel Hill.

x*Dr. Albert A. Michelson and His Contributions to Science.* J. B. DERIEUX, State.

x*The Mechanics of Effervescence.* OTTO STUHLMAN, Jr., U. N. C.

x*Lunar Periodicity in the Spawning of the Oyster* (Lantern). H. F. PRYTHERCH, Beaufort Laboratory.

Animals Living in Certain Sponges at Dry Tortugas (Lantern). A. S. PEARSE, Duke.

†*An Interpretation of a Case of Embryonic Variation.* H. V. WILSON, U. N. C.

x*A New Type of Transmutation.* CHARLES W. EDWARDS, Duke.

The Recovery of Natural Selection. WM. LOUIS POTEAT, W. F. C.

Honey Flora of North Carolina. F. B. MEACHAM, State.

x*The Narcotic Action of Lactic Acid* (Lantern). VERA KOEHRING, Beaufort Laboratory.

**The Effect of Various Chemicals on the Larva and Pupa of Culex pipiens at Various Temperatures.* B. J. BAROODY, Duke.

x*The Effect of Applications of Nitrate of Soda to Peach Trees during Dormancy* (Lantern). CARLOS F. WILLIAMS, State.

Preliminary Report on the Relation of Soil Moisture and Leaf Area to Fruit Development in the Peach. IVAN D. JONES, State.

†*Some Symptoms and Effects of Wind Injury on Fruit and Leaf* (Lantern). R. F. POOLE, State.

x†*Preparation of Motor Nerve Ending Slides from the Snake.* C. F. DODSON, Campbell.

A Cytological Study of Murgantia histronica Hahn. R. P. MOREHEAD, W. F. C.

Cytological Observation on Zoospore Formation in Leptolegnia caudata de Bary (Lantern). (Published in the Journal of the Elisha

Mitchell Scientific Society 47: 281–292, 1932.) A. C. MATHEWS, U. N. C.

x†*The Problem of Stream Piracy in Western North Carolina.* MARTHA E. NORBURN, U. N. C.

Barite in North Carolina. J. L. STUCKEY, State.

x†*Some Results of Electrical Prospecting for Oil and Gas* (Lantern). J. H. SWARTZ, U. N. C., and Bureau of Mines.

x*The Species and Distribution of Panicum in North Carolina.* H. L. BLOMQUIST, Duke.

The Problem of Culturing Plant Viruses in Vitro. FRANK H. JOHNSON, Duke.

†*Respiration of Erythrocytes of Marine Fishes.* F. G. HALL, Duke.

*†*On a Collection of Fishes from the Tuckaseegee and Upper Catawba River Basins, North Carolina, with a Description of a New Darter.* S. F. HILDEBRAND, Bureau of Fisheries.

†*The Generic Value of the Male Genitalia of the Fulgoridae* (Lantern). Z. P. METCALF, State.

Epidermal Cell Wall Structure in Aucuba japonica. D. B. ANDERSON, State.

**Absorption of Water by Leaves* (Lantern). HAROLD F. WILLIAMS, Duke.

x*A Consideration of the Forces Bringing about Absorption of Water by Transpiring Plants* (Lantern). PAUL J. KRAMER, Duke.

**Extended Ranges of Plants in North Carolina.* W. C. COKER and H. R. TOTTEN, U. N. C.

x*Experimental Studies on the Destructive Distillation of Cotton Seed Hulls.* E. E. RANDOLPH, C. S. GROVE, and R. C. TUCKER, State.

Eolian Soils of Our Coastal Plain (Lantern). COLLIER COBB, U. N. C.

A New Species of Bignonia. W. C. COKER, U. N. C.

MATHEMATICS SECTION

x*A Class of Solutions of the Heat Equation.* F. G. DRESSEL, Duke.

x*Curves in a Function Space with an Infinite Sequence of Non-vanishing Curvatures.* JOSEPH A. GREENWOOD, Duke.

x*An Example of a Crinkly Curve.* E. L. MACKIE, U. N. C.

x*Pfaffian Systems which are Derived Systems.* MABEL GRIFFIN, Duke.

x*The Region of Convergence of the Power Series for a Harmonic Function of Two Variables.* J. M. THOMAS, Duke.

x*Classification of Correlations in Space.* E. T. BROWNE, U. N. C.

PHYSICS SECTION

x*The Theory of a Perfect Gas on Quantum Principles.* E. K. PLYLER, U. N. C.

x*Capillary Action as a Function of Temperature and Pressure* (Lantern). F. WOODBRIDGE CONSTANT, Duke.

x*A New Formula for the Determination of Relative Humidity* (Reflection Lantern). F. W. LANCASTER, State.

x*Infra-red Absorption of the Nitrate Ion.* C. J. CRAVEN, U. N. C.

x*Anomalous Hysteresis in Rubber Elastics.* MILTON E. BRAUN, Catawba.

x*The Magnetic Field of High Frequency Solenoids.* SHERWOOD GITHENS, Jr., and OTTO STUHLMAN, Jr., U. N. C.

x*The Electrification by Friction between Solid Bodies and Gases.* C. MERRITT LEAR and OTTO STUHLMAN, Jr., U. N. C.

EXHIBITS

Rayon Machine (At work during the luncheon hour and late afternoon). M. M. CROOM, ALFRED GONZALES, E. E. RANDOLPH, State.

An Apparatus for the Photoelectric Measurement of Blood Cell Permeability. F. G. HALL, Duke.

The Phototronic Cell. MILTON L. BRAUN, Catawba.

Three Early French Maps of "Florida." COLLIER COBB, U. N. C.

Drawings to Illustrate the Generic Value of the Male Genitalia of the Fulgoridae. Z. P. METCALF, State.

Absorption of Water by Leaves. HAROLD F. WILLIAMS, Duke.

Differential Staining and Differential Solubilities as Indices of Epidermal Cell Wall Structure. D. B. ANDERSON, State.

Does a Snake have Legs? BERT CUNNINGHAM, Duke.

Some Living and Pressed Specimens of Panicum from North Carolina. H. L. BLOMQUIST, Duke.

Commercial Exhibits. PHIPPS and BIRD, Richmond, Va.

NORTH CAROLINA SECTION OF THE AMERICAN CHEMICAL SOCIETY

The following papers were presented.

Modification of the Shaffer-Hartmann Method for the Determination of Dextrose and Starch. J. O. HALVERSON AND F. W. SHERWOOD, N. C. Agr. Exp. Sta.

The Solubility of Ethylene Chloride in Aqueous Salt Solutions. J. H. SAYLOR and IMOGENE CLAIBORNE, Duke.

The Synthesis and Behavior of Certain Thiophanes in Hydrocarbon Solutions. R. W. BOST and MILLER CONN, U. N. C.

The System: Lead Acetate-Acetic Acid-Water. WARREN C. VOSBURG and GRADY TARBUTTON, Duke.

Oxidation-Reduction Potential as a Factor in Crop Production (Lantern). L. G. WILLIS, State.

A Comparative Study of Ald-and Keto-Chlorimines. C. R. HAUSER, E. MOORE, and H. HUMBLE, Duke.

The Aqueous Systems of Cupric Sulphate with Cobalt and Magnesium Sulphate. H. D. CROCKFORD and D. J. BRAWLEY, U. N. C.

Elementary Fluorine in Organic Chemistry (Lantern). L. A. BIGELOW, J. HERBERT PEARSON, LOUIS B. CROOK, and GEORGE J. HAUS, Duke.

Ternary Systems: Water, Tertiary Butanol, and Salts. P. M. GINNINGS, ETHEL HERRING, and BAILY WEBB, G. C. W.

Cymyl Orange, a New Indicator. A. S. WHEELER, J. H. WATERMAN, U. N. C.

Relation of Constitution to Chemical Reactivity in the Cleavage of Certain Organic Esters (Lantern). R. N. ISBELL, W. F. C.

The following abstracts have been received.

An Old Botanical Puzzle. FREDERICK A. WOLF.

This address consisted of an historical résumé of the literature concerning a tobacco disease called frenching, together with a review of theories as to its cause. The disease was first described nearly 250 years ago, yet no satisfactory explanation of its cause has been published. The writer's observations and experiments were recounted in a way to show how the problem of the cause of frenching might be attacked. Apparently the disease is due to a mineral deficiency, induced by excess of calcium. Critical tests, upon which special emphasis was laid, showed that frenched tobacco plants could be made to absorb, through exposed root tips or through leaf tips, sufficient manganese to result in recovery. The completed study will be presented subsequently in another form.

Effect of Increased Atmospheric Pressure on the Development of Hen's Eggs. (Report of Progress) B. CUNNINGHAM.

The studies for the most part during the present egg laying season

have been concentrated upon the effect of 20 pound pressures. In early development (3 days to 5 days) acceleration is quite evident, at 11 days the differential is not so great, and hatching time is not reduced. Chicks will hatch however under this pressure and live for several days. The three chicks hatched had some defect of legs which appeared to be due to a lack of moisture when hatching occurred. Many eggs developed to the 18th day. At 20 pounds pressure a temperature of 100°F. killed a large number of embryos at about 10 days. Some survived under these conditions at least until the 18th day when an extreme rise of temperature in the incubator caused death to all the embryos.

Copper Content of Some Foods. G. HOWARD SATTERFIELD and S. O. JONES.

Copper content of foods is important because of relationship to anemia. Lindow, Elvelijen, and Peterson have made extensive determinations of copper in foods.

The following foods produced in Franklin County, N. C., were analyzed for copper content, the figures being mg. per kg. of dry material:

White potatoes	6.5	Lima beans	8.6
Yellow potatoes	4.1	White corn	5.95
Black grapes	8.1	Yellow corn	16.6
Navy beans	10.45	Pop corn	6.6
Black eyed peas	7.36		

Bluestain Fungi as a Factor in the Death of Southern Pines Attacked by Bark Beetles. RALPH M. NELSON.

Pine trees die after attack by the southern pine beetle (*Dendroctonus frontalis* Zimm.) within a few weeks. The beetles excavate tunnels in the phloem and cambium region into which they carry the bluestain fungus, *Ceratostomella pini* Münch. The fungus grows rapidly to form wedge-shaped sectors in the sapwood. Results of inoculation experiments indicate that the fungus, independent of bark beetles, is able to kill pines and that the transpiration current is unable to pass through the stained sectors. The conclusion is reached that the rapid death of pines attacked by the southern pine beetle is caused by the associated bluestain fungus, *C. pini.* Aspiration of tori in the bordered pits of the water conducting tracheids through the action of *C. pini* in the parenchyma cells of the medullary rays is advanced as the cause of the stoppage of the transpiration current.

Specific Differences in Basal Wounding by Fire of Southern Appalachian Hardwood Trees. I. H. SIMS.

Recurrent forest fires in the past have contributed largely to the present poor condition of many stands of hardwood timber in the Southern Appalachian Mountains. One of the more important forms of damage inflicted by these forest fires is the opening of wounds at the bases of the tree boles. These wounds reduce the growth rate of the trees and serve as avenues of entrance for wood rotting fungi.

The relation between external discoloration and wound was studied on approximately 300 trees following a spring forest fire; five species were included, white oak, black oak, chestnut oak, scarlet oak, and yellow poplar. Curves were developed, for each species, from which the area of wound can be estimated from the width and height of the area of discoloration.

In general, yellow poplar was found to have the smallest wounds for a given area of discoloration and scarlet oak the largest. The other three species occupied intermediate positions, their relative order depending on the size of the tree and of the discoloration. Chestnut oak showed the highest correlation between wound area, diameter at breast height, and the product of width and height of discoloration. Chestnut oak was followed in descending order by black oak, yellow poplar, white oak, and scarlet oak.

Pronunciation of Scientific Words. GEORGE W. LAY.

Words are spoken as well as written. It is as important to use the correct pronunciation as the correct spelling. Most people spell the most difficult words correctly, but many use a wrong pronunciation. Most mistakes are with regard to the accent. There is great lack of uniformity and even the experts do not agree among themselves.

Few have the dictionary habit and many common scientific words are not yet in any dictionary. The accent of words from Greek or Latin depends on a simple rule that deals with the quantity of the penult. This requires a slight working knowledge of these languages. Few have this knowledge, or use it if they have it. We pronounce words as we have heard them pronounced. Hence there is a great responsibility laid upon the leaders in any science, since their mistakes are sure to descend to many generations.

Anyone who invents a scientific word should publish the pronunciation as well as the spelling. Textbooks and lists of names should at least have the proper accent plainly indicated. As it is, a student is

entirely at sea and can only imitate his instructor, who may himself be wrong.

Doctor Albert A. Michelson and His Contribution to Science. J. B. DERIEUX.

Born in Germany	1852
Elementary school education, Nevada and San Francisco	
U. S. Naval Academy, graduate	1869–1873
Mid-shipman, U. S. Navy	1873–1875
Instructor in physics, Naval Academy	1875–1879
Nautical Almanac office	1880
Studied at Universities of Heidelberg, Berlin, Paris	1881–1883
Case School of Applied Science, professor of physics	1883–1889
Clark University, professor of physics	1889–1892
University of Chicago, professor and head of physics	1892–1929
Died in Los Angeles, California	May 9, 1931

Member of International Weights and Measures Commission	1892, 1897
Lowell lecturer	1899
Exchange professor, Gottingen	1911
Distinguished Service Professor, University of Chicago	1925

1. Improved method for velocity of light	1878
2. Measured the velocity of light (2000 ft.)	1879
3. Measure for ether drift	1881
4. Invented Michelson interferometer	1882
5. Measured velocity of light (4 miles)	1882
6. Determined velocity of light in water and carbon disulphide	1884
7. Determined influence of velocity of medium upon the velocity of light	1886
8. Performed famous Michelson and Morley experiment upon ether drift	1887
9. Measured the diameter of Jupiter's satellites	1891
10. Resolved fine structure of spectral lines	1892
11. Measured wave lengths of light in standard meter	1893
12. Separated components of Zeeman effect	1897
13. Invented Michelson-harmonic analyzer	1898
14. Invented Michelson eschelon spectroscope	1900

15.	Analyzed sun spot cycle	1913
16.	Measured tides in earth's crust	1914
17.	Ruled and tested a 10-inch diffraction grating	1915
18.	Determined diameter of Alpha Orionis	1921
19.	Measured velocity of light (22 miles)	1924
20.	Determined velocity of light (22 miles, polygon mirrors)	1926
21.	Repetition of Michelson and Morley experiment	1928
22.	Measured velocity of light *in vacuo*	1931

Contributed more than seventy-nine articles to scientific journals.

1.	Rumford Medal	1889
2.	Grand Prix, Paris Exposition	1900
3.	Mattenci Medal, Soc. Italiana	
4.	Copeley Medal, Royal Society	1907
5.	Nobel Prize	1907
6.	Cresson Medal, Franklin Institute	1912
7.	Draper Gold Medal, National Academy of Sciences	1916

Member of sixteen scientific societies, at home and abroad
Honorary Fellow of eleven societies
President of American Association for Advancement of Science 1887, 1910
President of American Physical Society 1901–1903
President of Philosophical Society 1910, 1911, 1913

He had his own flower garden; played golf and tennis at sixty-five years of age; his paintings attracted considerable attention.

Contributed in loving memory of him, by a student of his.

The Mechanics of Effervescence. OTTO STUHLMAN, JR.

Bubbles of gas when released in a liquid at depths great compared to their diameters burst on reaching the surface and eject droplets of the fluid into the air. Each bubble whose diameter is less than a critical value, as determined by the characteristics of the liquid, on bursting ejects simultaneously many droplets. Their distribution in height is logarithmic with the greater difference in height between the higher

ones. For water at 21°C. maximum droplet ejection was 14 cm. for a critical bubble diameter 0.12 cm., benzene bubbles were less stable, rose to a height of 9.0 cm. for 0.15 cm. at 22°C. Bubbles less than 0.10 cm. diameter eject droplets to a height proportional to the three halves power of the radius. Bubbles having diameters greater than above critical values, burst irregularly. Irregularity is attributed to instability of bubble. Variation in distribution amongst any given group of droplets at a given height is near Maxwellian. Lower boundary sharp, with a more straggling distribution for larger values of height.

Theory of ejection herewith developed pictures the bursting bubble accompanied by a gas vortex ring which assists in raising the liquid jet, of contour hx = constant, and volume hx^2 = constant. Instability in rising volcano-like jet produces drop formation, which vortex ring redistributes so that log h decreases proportionally as the number of drops increases linearly.

Lunar Periodicity in the Spawning of the Oyster. HERBERT F. PRYTHERCH.

In certain coastal areas oysters discharge their spawn during certain phases of the moon. Studies, in Long Island Sound and at Beaufort, N. C., show that these activities usually take place from 6 to 9 days after either full moon or new moon. Indirectly the moon is responsible for spawning at such times because of its influence on the tides and water temperatures. During the spring tides which occur at times of full or new moon there has been recorded in the early summer an increase in water temperature of 8° to 10°C. The higher tides during these periods cause the water to pass over a greater area of tidal flats where it absorbs considerable heat from the land and sun's rays.

The ripe oysters spawn when the water reaches a temperaure of 20°C. or above. Since the highest temperatures have been found to occur several days after the time of full or new moon it is apparent that this factor is directly responsible for the relation between the moon's phases and oyster spawning.

A New Type of Transmutation. CHARLES W. EDWARDS.

The discovery of radioactivity by Becquerel in 1896 led directly to the discovery by Rutherford and Soddy in 1902 of the transmutation of one element into another element of quite a different atomic weight. This type of transmutation is shown in the series of products resulting from the breaking up of the uranium atom and the thorium atom, both

of which result in the formation of lead as an end product. This type of transmutation has its seat in the atomic nucleus and is the result of the breaking up of the nucleus.

A second type of transmutation is brought about in a very hot arc or a very hot spark. Under such conditions the atom will be stripped of some of its orbital electrons. Aluminum, for instance, has 13 orbital electrons of which 3 lie in the outer shell. If the atom is stripped of one electron, magnesium results. If the atom is stripped of two electrons, sodium is produced.

A third type of transmutation recently effected is in adding protons, or alpha particles, to the nucleus rather than subtracting matter from it. Bode and Becker in Germany have produced carbon by adding one proton to the nucleus of beryllium. Cockroft and Walton have produced two helium atoms by adding one proton to the nucleus of lithium.

The Narcotic Action of Lactic Acid. VERA KOEHRING.

Lactic acid proves to be an efficient narcotic for the oyster. Much information is available in regard to lactic acid metabolism. In addition, the study of lactic acid as a narcotic may add not only to the knowledge of the general rôle of lactic acid in the body but, more specifically, to the understanding of the problems of narcosis and sleep.

The Effect of Applications of Nitrate of Soda to Peach Trees During Dormancy. C. F. WILLIAMS.

Nitrogen was assimilated by the roots of dormant seedling peach trees kept at temperatures of 35°F. or above as indicated by greater percentages of total nitrogen in the roots as compared with unfertilized trees maintained at the same temperatures. At 20°F. no increases in total nitrogen in the roots were found. Determinations for total nitrogen in the tops, however, gave no evidence of nitrogen translocation to the tops at temperatures of 45°F. or lower. Out of doors and in the greenhouse the total nitrogen in the tops increased in percentage amounts. With mature Elberta peach trees in the sandhills of North Carolina, applications of nitrate of soda during dormancy did not increase the percentage amount of total nitrogen in the fruiting wood during the winter, although similar applications made at other times of the year produced increasing percentage amounts of total nitrogen that were in general proportional to the rate of application. However, trees responded in growth and fruiting the following season.

Preparation of Motor Nerve Ending Slides from the Snake. CLINTON F. DODSON.

The snake furnishes an ideal type of muscle to use in the preparation of motor nerve ending slides. Perhaps the large fast running snakes, such as the coach-whip and black snake, are the best types to use as they have less fat around the muscle and the muscle is firmer and stronger, rendering it more suitable for handling and teasing.

The snake, having been killed, should be split open from mouth to anus and all internal organs removed. The skin is then removed by cutting down the dorsal side from one end to the other and pulling it apart from dorsal to ventral. The skin should be pulled apart a little at a time all the way back from head to tail. This will prevent breaking the little muscle bands that are to be used in the preparation. As the skin is being removed, small bands of muscle can be seen passing out from under the transverse processes and extending ventrally to become inserted in the skin on the belly portion. These muscles taper from the transverse processes to a very thin band at their insertion. As much of this thin muscle as possible should be left hanging to the snake, since this part is the best to use in the motor nerve ending preparation.

After the snake has been skinned it should be cut up into pieces of about one inch in length, washed and placed in a 25% solution of formic acid and left here for ten hours. The pieces are then transferred to a 0.50% solution of gold chloride and left in this for twelve hours or more. They are next washed in running water for ten minutes and placed in a 25% solution of formic acid and left over night. From the formic acid they are washed in running water for ten minutes and placed in a 50% solution of glycerine and left here for ten hours; then put into pure glycerine. The material should stand in pure glycerine at least eight hours before putting on the slide. We find that the pieces of snake may remain in this pure glycerine for more than a year and still be in a perfect state of preservation. If it is to be left here for a period of a year or more, 2 cc. of 5% solution of carbolic acid should be added to each pint of glycerine.

In putting the muscle band on the slide, care should be taken to get a thin piece with as little fat on it as possible. This type of muscle is best located on the belly region, near where the snake was split open. The little band of muscle should be raised up with the needle and clipped back near the transverse process. The piece of muscle will cling to the needle and can be easily lifted off and placed on a slide. A small drop

of glycerine is then put on the muscle to keep it from drying out during teasing. The muscle fibers are then teased apart with glass needles. If the proper type of muscle has been secured there will be but little teasing to be done. After the fibers have been properly teased apart and the nerve endings are located, a drop of glycerine jelly is placed on the muscle. This drop should be about the size of a garden pea and should be in a semi-fluid state, just warm enough to prevent bubbles and cool enough to prevent spreading without pressure exerted upon it. The cover glass is then placed on, allowing its central portion to come in contact first with the jelly. The cover glass is then gently pressed down causing the jelly to spread out in all directions, thereby making the muscle fibers spread with the jelly and the nerve endings show up better. If the proper amount of jelly has been used the jelly will just reach to the outer edges of the cover glass and there will be no glycerine jelly to clean off around the edge before ringing. In ringing, a turn table is needed. It can be rung with any one of several materials, such as Duco, cement, demar, etc.

The Problem of Stream Piracy in Western North Carolina. MARTHA E. NORBURN.

The mountain region of North Carolina is not only the culminating portion of the Appalachian Mountains, but also has the most intricate stream pattern of the range. In the study of the streams of this region will be found the solution of many of the problems of the Appalachian Mountains.

In Grandfather Mountain, the highest mountain of the eastern range, rise rivers which flow to all points of the compass. Of these interesting rivers, the Linville has been classed as a pirate stream, the evidence being based chiefly on the high level valley above the falls. The peculiar course of the Linville might be due to the highly resistant rock of the gorge. Grandfather Mountain certainly owes its height to its highly resistant rock. The dip of the strata of the gorge of the Linville River is toward the falls.

Within the mountain region proper, the stream pattern is intermediate between the dendritic and the parallel. Map study shows many barbs which would indicate extensive piracy among the smaller tributaries. Geologic maps also show weak strata of rock associated with the barbs.

A stream which has been under observation since Professor Collier Cobb visited the region sixty years ago is Hominy Creek. In its upper stretches, this stream has a clearly defined barbed valley and has appar-

ently captured North and South forks from Pigeon River. The proof of capture seems to be in the long gap and in the systematic arrangement of the barbs. However, the position of the belts of hard and soft rock and the relationship of the planes indicate structural control. This is further indicated by the many narrows and minature flood plains along the courses of the forks. Since structural control is so important in the formation of the Appalachians, the problems is complicated not only in the case of the Hominy, but in the case of the numerous barbs of other streams. Should the piracy hypothesis be followed, the argument should rest, as it did when it was first studied, on the relationship of the barbs and the gap. The extent of structural control enters into the problem. The solution will have a direct bearing on the peneplains of the Appalachians, the piedmont, and the Great Valley.

Some Results of Electrical Prospecting for Oil and Gas. J. H. SWARTZ.

Following a resistivity survey, predictions were made concerning the character of 8 distinct horizons and the depth at which they would be encountered in a proposed wildcat well. The well when drilled encountered all 8 horizons with an average error only one half of that to be expected from the depth intervals used in the survey, proving: (1) the location of oil and gas horizons by the partitioning method is feasible, and (2) the assumed depth relationships are (a) correct and (b) unaffected by stratigraphic complexity. The most sensitive detection was that of a 4 foot gas sand at a depth of 160 feet, indicating that an oil or gas sand whose thickness is as little as 0.6% of the depth should prove detectible.

A second survey was run across the new Legrande pool in Hart County, Kentucky. The pool was outlined and its boundaries determined purely by resistivity methods. Subsequently logs and production data were collected from approximately 150 wells and a second outline determined on the basis of drilling data. The two outlines coincided in every detail, with an error less than the uncertainty of the drilling data.

The Species and Distribution of Panicum in North Carolina. H. L. BLOMQUIST.

This paper dealt with results of further investigation into the grasses and their distribution in North Carolina, especially the species of *Panicum*. The author stated that so far 252 species of grasses have been collected from the state and that over 50 more, not included in the above, have been collected and reported by other investigators. These

latter data have been obtained from visits to several other herbaria. It was estimated that the total number of species of grasses included within the area of the state will be found to be considerably above 300 species. This large number of grasses is apparently largely due to a large number of species of *Panicum.* Eighty-nine species of this genus have been reported from the state out of which 75 have been collected by the author. Some interesting features in the distribution of these species showing the operation of distinct edaphic and climatic factors were pointed out.

A Consideration of the Forces Bringing About the Absorption of Water by Transpiring Plants. PAUL J. KRAMER.

Most botanists agree that the movement of water from the roots to the leaves of plants occurs as a result of the tension developed in the water conducting system by the loss of water in transpiration. However, there is much disagreement as to the forces concerned in the movement of water from the soil across the cortex and into the xylem vessels of the root. It appears that the complex of factors bringing about the absorption of water in freely transpiring plants may be quite different from that bringing about absorption at times when little transpiration is occurring.

Experiments in which the conditions occurring in the conducting vessels during transpiration were partially duplicated by attaching a vacuum pump to the cut stems of plants indicate that reducing the pressure within the conducting vessels materially increases the absorption of water. This fact supports the view that the movement of water from the soil into the xylem of the roots is probably due to the existence of a gradient of decreasing pressure from the exterior to the interior of the roots. This pressure gradient results from the state of tension set up in the hydrostatic system of the plant by the removal of water in transpiration.

Such a view of the process of absorption reduces the rôle of the living cells of the roots to that of passive absorbing surfaces, a rôle which might in some respects be filled as well by dead as by living roots. This view is supported by the fact that several species of plants have been kept alive for one to two weeks after their roots had been killed.

During times when the moisture content of the soil is low, the living cells of the roots play an important, but indirect part in absorption through the extension of the root system by growth. This brings the absorbing surfaces in contact with new supplies of water which would otherwise be unavailable.

Experimental Studies on the Destructive Distillation of Cotton Seed Hulls. E. E. RANDOLPH, C. S. GROVE, and R. C. TUCKER.

A complete analysis was made of the cotton seed hulls previous to the destructive distillation studies. The analysis indicated that the hulls would be an excellent raw material for distillation. Destructive distillations were carried out on cellulose and lignin compounds obtained from the hulls and on the hulls themselves. The distillation of the hulls gave 29% gas, a heat value of 300 B.t.u.'s per cubic foot, 41.5% liquid, and 29.5% charcoal of a heat value ot 12,500 B.t.u. per pound. The liquid was divided into aqueous solution 35% and tar 5%. Each of these portions was analyzed: the gas for heat value, specific gravity, oxygen, carbon dioxide, carbon monoxide, illuminants, hydrogen, and methane; the aqueous distillate for total acidity, acetic and formic acids, dissolved tar, furfural, specific gravity, methyl alcohol, esters, and acetone; the tar fraction for total acidity, specific gravity, phenols, and creosotes; the charcoal for heat value, color adsorption power, nitrogen, and soluble potash.

This showed that the acetic acid content is high enough to render the recovery industrially attractive. It was found that the tar is hard drying and unusually resistant to the common chemical reagents and solvents. Its high phenol content gives it promise of importance in the control of fungi which attack hard woods.

A Class of Solutions of the Heat Equation. F. G. DRESSEL.

Consider the Poisson-Stieltjes integral for the heat equation

$$\mu(x, y) = \left(\frac{1}{2\sqrt{\pi}}\right) \int_a^b \left(\frac{1}{\sqrt{y - \eta}}\right) e^{-\mu(\xi)}\, d\, F(\xi)$$

where $\mu(\xi) = \dfrac{(x - \xi)^2}{4(y - \eta)}$ and $F(\xi)$ is a function of limited variation with regular discontinuities. Under slight restrictions as to the manner in which the point (x,y) approaches an interior point x_0 of the interval (a, b) on the characteristic $y = \eta$, $\mu(x,y)$ is shown to take on the value $F'(x_0)$ whenever this exists. If F (t,y) denotes the integral from *a* to *t* of $\mu(x,y)$ with respect to x, then the limit $_{y \to \eta}$ $F(t,y) = F(t) - F(a)$.

Curves in a Function Space with an Infinite Sequence of Non-vanishing Curvatures. JOSEPH A. GREENWOOD.

f(x,s) is assumed to be expressed in the form of $\sum_{i=1}^{n} \psi_i(s)\phi_i(x)$, where

the ϕ_i (x) are a set of functions normed and orthogonal over the interval ($\alpha \leq X \leq \beta$), and s is arc-length, the parameter of the curve. A generalization of Frenet's formulas for the curvatures and normals is set up, as done by L. Ingold. The equations of the curves with constant curvatures are then found of the form f (x,s) above, and general expressions for any curvature. When n becomes infinite and the curvature formulas generalized, a proof by induction shows that within certain choices of the arbitrary constants for convergence properties, the curvatures do exist to infinity and that none is zero.

An Example of a Crinkly Curve. ERNEST L. MACKIE.

A particular function is defined geometrically at every point of a given finite closed interval on the x-axis as the limit of the values of a sequence of functions defined at a set of rational points only. It is shown to be continuous at every point, but nowhere to have a derivative.

Pfaffian Systems which are Derived Systems. MABEL GRIFFIN.

This paper gives in invariantive form a necessary and sufficient condition that r given equations be the derived system of some system of $r + 1$ equations. It also discusses to some extent the more general problem of finding k equations which, adjoined to a system S, yield a system having S for derived system.

The Region of Convergence of the Power Series for a Harmonic Function of Two Variables. J. M. THOMAS.

Let a power series in a complex variable converge in a circle C. If the sum is represented by $u + iv$, the domain of absolute convergence of the power series for u and v is proved to be the interior of the square which is inscribed in C and which has its diagonals in the coördinate axes. Thus is obtained a new and simple proof of a result first found by Bôcher to the effect that the region of convergence for the power series representing a harmonic function u is at most the square together with segments extending from its vertices along the axes.

Classification of Correlations in Space. E. T. BROWNE.

A correlation in space is a continuous 1–1 correspondence between the points x and the planes u of space such that all the points on a plane correspond to all the planes through a point. Analytically, such a correspondence is given by the equations

$$\rho u_i = \Sigma a_{ij} x_j, \qquad (i = 1, .., 4). \tag{1}$$

If as a plane turns about a point P, the points corresponding to this plane all lie in the plane which corresponds under (1) to P, P is said to be a point of a *double pair*.

The coördinates y of a point P of a double pair are found as solutions of the system of homogeneous linear equations

$$\Sigma\,(a_{ij}-\lambda a_{ji})y_j = 0 \qquad (i = 1, .., 4),$$

where λ is a constant different from zero. The number of solutions of this system of equations depends on the *rank* of the system or of the matrix $A - \lambda A'$. Since the calculation of the rank would prove quite difficult in the general case, in this paper the matrix A of the coefficients is reduced to the canonical form

$$\left\|\begin{array}{cccc} a & h & -g & l \\ -h & b & f & m \\ g & -f & c & n \\ -l & -m & -n & d \end{array}\right\|$$

By employing this scheme, which can be done with no loss of generality, it is shown in this paper how a complete classification of non-singular correlations in space can be effected by means of the roots of the equation $|A - \lambda A'| = 0$ and the rank of the matrix $A - \lambda A'$.

The Theory of a Perfect Gas on Quantum Principles. E. K. PLYLER.

It is shown that the specific heat of a perfect gas decreases at low temperatures according to the cube of temperature. The entropy changes become constant as called for in the Nernst heat theory. Further comparison will be made between a perfect gas on classical theory and the quantum theory.

Capillary Action as a Function of Temperature and Pressure. F. WOODBRIDGE CONSTANT.

Consideration of the pressure just beneath the meniscus of a liquid in a capillary tube shows that the rise of a liquid due to capillary action is limited at low pressures or for very fine capillaries by the gas pressure above the liquid, although the simple theory of surface tension does not predict this. Thus as the air pressure is gradually reduced, a capillary column of water, e.g., 20 cm. high, is at first unaffected, then falls steadily. The effect begins at an air pressure of about 3 cm. and the fall is then a linear function of the pressure, indicating no capillary rise

in a vacuum. For a constant pressure the effect of temperature is small, but above about 20 degrees C. the vapor pressure of the water prevents the attainment of the low pressures necessary for the effect. Capillary action in tall trees is hence limited to about 32 feet. The effect might be used for a low pressure control. However, liquids which are depressed in capillary tubes, such as mercury in glass, do not show the effect.

A New Formula for the Determination of Relative Humidity. F. W. LANCASTER.

From theoretical consideration, relative humidity is concerned with the vapor pressure at a given temperature and the pressure of the saturated vapor at that temperature. In most laboratory methods the use of wet and dry bulb temperatures involves the necessity of thermometer corrections, accurate pressure corrections with corresponding vapor pressure tables, barometric pressure, and a check against psychrometric tables.

The following work gives the development of an equation which may be of interest in that it involves only the relations between three arbitrary temperatures taken together, the dew-point, dry bulb, and wet bulb temperatures, without any consideration of any pressures, calibrations, corrections, nor necessity of any vapor pressure of psychrometric tables.

By the use of psychrometric tables from experimental work taken by the Bureau of Standards, curves were plotted coördinating relative humidity with dew-point, the square root of the dew point, dry bulb temperatures, logarithm of the dew-point, and the difference in the wet and dry bulb temperatures. Curves were also plotted for constant humidity against dry bulb temperatures for a constant difference in wet and dry bulb readings. By using arbitrary constants in a general function and solving the function, the general equation for relative humidity became

$$H = \frac{(D \log t_d)^{1/2}}{(t_d - t_w)} \{[t_d - t_w + 55] \log (t_d - t_w + 1) - (t_d - D)\}$$

where H = relative humidity.
D = dew-point in degrees Fahrenheit.
t_d = dry bulb temp. degrees Fahrenheit.
t_w = wet bulb temp. degrees Fahrenheit.

The equation checks experimental values for relative humidity over

a large range of temperatures beyond the normal need, and also gives an inference that there may be a possible correlation between the function used in the equation and the absolute entropy found for polyatomic molecules with which we are dealing in this case.

Infra-red Absorption of the Nitrate Ion. C. J. CRAVEN.

The study was made to see if the absorption of the nitrate ion is essentially the same as that due to nitrate salts. The infra-red data seem to show very nearly the same absorption for all nitrate ions irrespective of their origin. This indicates that when the nitrate ion has a double grouping in a salt, it is separated in solution. The structure and certain characteristics of the ion will be discussed in connection with its infra-red spectrum.

Anomalous Hysteresis in Rubber Elastics. MILTON L. BRAUN.

Hook's law, which states that the elongation in an elastic body is proportional to the force which produces it, is not applicable to a rubber band or elastic. There is not only absence of a linear relation between stress and strain, but also a decided lack of coincidence in the relationship when the stretching force is increasing and when it is decreasing. This latter phenomenon is called hysteresis. The hysteresis effect is indicated by the area between the curves resulting when elongation of the rubber is plotted as a function of the stretching load, first as the load is slowly increased to a maximum, and then as it is gradually reduced to zero. The hysteresis loop bears no axis of symmetry. Its shape is dependent upon the kind of specimen, the history of the specimen (whether under prolonged stretch just prior to the test, etc.), the magnitude of the load, upon time, and upon temperature. The maximum range in load for one elongation falls at a point within 85 to 95 per cent of the total elongation, while the minimum range lies at a less sharply defined point somewhere between 10 and 25 per cent of the full stretch for a given test. The maximum range in elongation for one load varies widely with different specimens, sometimes being at a point about one fourth and again about three fourths of the entire elongation. For the average specimen it lies at approximately 60 per cent of the full elongation.

The physical significance of the area bounded by the curve, the ordinate axis, and the elongation limits, is its indication of energy: the area under the first curve representing the work done on the rubber by the

stretching forces, that under the second curve showing the work accomplished by the elastic in lifting the remaining weights as they are removed one at a time. The difference between these two, represented by the closed area between the curves, indicates a loss in available energy. Mathematically the ratio of this loss to the work spent is expressed as:

$$\int_0^e (w\,dy - u\,dy) \Big/ \int_0^e w\,dy$$

where y is the elongation in centimeters, e the maximum elongation, w the load function in dynes as the load is increasing, and u the same as the load is decreasing. Integrations were evaluated by the trapezoidal rule. A representative specimen showed for 900, 1200, 1500, and 2100 gram maximum forces losses of 7.2, 14.6, 19.0, and 25.7 per cent or 0.88, 2.52, 3.94, and 6.16 $\times$ 10^6 ergs, respectively. These forces correspond to elongations of from 75 to 125 per cent of the original length of the elastic.

For a given specimen, with time intervals between each reading of 0.1, 1.0, and 5 minutes, the respective losses were 26.2, 19.0, and 17.7 per cent, or 6.05, 3.94, and 3.64 $\times$ 10^6 ergs. It is evident that the more time the rubber is given in which to come to equilibrium the smaller the loss becomes.

The effect of temperature was not investigated.

The Magnetic Field of High Frequency Solenoids. SHERWOOD GITHENS, JR., and OTTO STUHLMAN, JR.

The internal and external magnetic fields of a helical solenoid oscillating at radio frequencies were investigated on account of the frequent use of such solenoids in producing the electrodeless glow discharge. Published data were found to be indefinite and were probably arrived at by analogy to the field secured with direct current excitation. These experiments show that the analogy was justified and correct in the broadest sense, but that minor and rather important differences arise when high frequency is used, and that these differences are dependent upon the degree of symmetry of the wave form. It was found that the wave shape is dependent upon the type of oscillator used, and that the different types give characteristic fields. Several types of vacuum tube oscillators were considered, and curves showing the characteristic fields excited in solenoids were displayed.

The Electrification by Friction Between Solid Bodies and Gases. C. MERRITT LEAR and OTTO STUHLMAN, JR.

Electrification by means of friction between solid bodies and gases was reinvestigated on account of the contradictory results of previous work. The bombardment of an iron collector by means of mercury vapor at a constant temperature has led to some rather new theories in regard to this phenomenon.

The pressure, temperature, and vapor flow being kept constant there was an accumulation of negative charge on the collector. This charge was found to slowly drop to zero after reaching a maximum of about 250 volts on continued bombardment. These results seem to indicate that the charge on the collector was not due to friction between the collector and the vapor but due to that of friction between the vapor and the film of adsorbed gas on the collector.

H. R. TOTTEN, *Secretary*

PROCEEDINGS OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY

October 13, 1931, to May 10, 1932

330th Meeting, October 13, 1931

E. K. Plyler: *The Arrangement of Atoms in Certain Molecules.*

In recent years the theory of infrared spectra has made a correlation between the absorption of infrared radiation and the structure of molecules. In the case of the simple triatomic molecules N_2O, CO_2, and H_2S it has been found that the three atoms composing the molecule are arranged in a straight line. However, it is found that N_2O is not symmetrical, but that the two nitrogen atoms are on the same side of the oxygen atom. Water vapor is a triangular molecule. The angle between the lines joining the two hydrogen atoms to the oxygen atom is 115 degrees.

The work is being extended to apply to other types of molecules.

R. W. Bost: *A New Method for the Identification of Mercaptans.* (By title.)

331st Meeting, November 10, 1931

F. H. Edmister: *The Behavior of Oxalate and Tartrate Solutions of Columbium and Tantalum Oxides.*

Collier Cobb: *Mineral Resources of the Egyptian Desert.* (Illustrated.)

332nd Meeting, December 8, 1931

E. W. McChesney: *Liquid Ammonia as a Medium for the Study of Organic Compounds.*

The chemistry of the liquid ammonia system has been very thoroughly worked out by Franklin and Kraus and others who have followed them. In particular, Johnson and Fermelius have summarized the work which has been done in a series of articles in the Journal of Chemical Education. In these articles they point out the marked resemblance between liquid ammonia and the two solvents most commonly used, namely, water and alcohol. On account of its marked resemblance to water, liquid ammo-

nia has been used a great deal in the study of inorganic compounds, and with considerable success. However, it dissolves quite readily a number of organic compounds, resembling in this respect alcohol more than it does water. Because of this solubility relationship, liquid ammonia has been applied recently to the study of organic compounds and in particular to those reactions involving reduction. The alkali metals dissolve readily in ammonia and form excellent reducing media. The reduction of phenyl chloride to benzene and of cystine to cysteine, for example, have been carried out in ammonia with sodium or potassium as the reducing agent.

McChesney and Miller (Journ. Amer. Chem. Soc. **53**: 3888. 1931) studied the reduction of proteins by a solution of sodium in liquid ammonia. The proteins were found to be highly acidic in character, taking up one atom of sodium for each atom of nitrogen in the molecule, and releasing hydrogen. The products were white powders having strong reducing properties. The powder could be esterified readily and the free base formed from the ester could be isolated in the form of its picrate. The latter was crystalline, indicating that the base could not have a very high molecular weight. A study of type compounds such as dipeptides and diketopiperazines indicated that there may be diketopiperazine rings in the protein molecule, since the latter behaved more like the proteins than did the peptides.

J. G. DOUGLAS: *Petroleum Development in the Maracaibo Basin.* (Illustrated.)

The Maracaibo Basin is a relatively small geosynclinal trough in western Venezuela, lying between the Sierra de Perija on the west and the Venezuelan Andes and the Serrania de Trujillo on the south and east. It is occupied by a large shallow body of water known as Lake Maracaibo.

Sediments have been accumulating in the basin over a long period of time and many oscillations between brackish or fresh water and marine conditions have occurred. At present the waters in the basin are rather fresh, being connected with the Caribbean Sea by only a narrow shallow passage, the Straits of San Carlos.

Rich deposits of petroleum are found in some of the Cretaceous and Tertiary deposits of the basin, occurring in minor folds along the flanks of the major structure, and, after the granting of the first important concessions to foreign operators in 1907, Venezuela advanced to second place among oil producing countries in 1928.

Brief descriptions of Mene Grande, La Rosa, Ambrosio, Lagunillas, El Mene, La Paz, Concepcion, Misoa-Zo-Menito, Totumo, Rio Tarra, and Rio de Oro fields were given.

333RD MEETING, JANUARY 12, 1932

LANDIS BROWN: *A Report of a Case of Ovarian Pregnancy.*

Specimen obtained from operation for ectopic pregnancy at the Johnson County Hospital. The anatomical relations and the presence of ovarian stroma led to the identification of the mass as an ovary. Embedded in it was a chorionic vesicle with well developed villi. Inside the vesicle was an 11 mm. embryo, apparently normal in gross appearance.

N. W. DOCKERY: *Cotton as a Source of Cellulose.*

334TH MEETING, FEBRUARY 9, 1932

A. M. WHITE: *On the Discovery of Palladium.*

The discovery of palladium was announced by means of an anonymous notice. This unusual procedure led to a controversy in which Richard Chenevix, F. R. S., held that palladium was a fraud, and other chemists including Wollaston maintained that it was a new element. Wollaston ultimately admitted that he was the discoverer of palladium, and that he had adopted this unusual mode of announcement to secure priority without full disclosure. Chenevix was discredited and retired to France.

T. F. HICKERSON: *Analysis of Continuous Multiple Spans.*

In any multiple-span arrangement, the following statements are arbitrarily used to govern the determination of maximum moments and shears: (1) The effect of loads on remote spans is so small that it may be neglected for purposes of design; and (2) the span arrangement beyond any support may be imagined removed if a known equivalent restraining moment is substituted therefor.

Coefficients giving the bending moment or shear at the end or middle of any span have been evaluated in terms of fixation factors at certain sections. The aforesaid factors express the relation between the actual bending moment at a section and that occurring under fixed conditions.

It was explained how the so-called fixation factor had been measured with a "mathematical yardstick" so as to represent the restraining effect of any system of columns or beams beyond the section in question.

As a general treatment of multiple spans, three cases were considered: (1) Maximum moment and shear at the terminal support; (2) maximum moment and shear at any interior support; and (3) maximum moment at the middle of any interior span.

335TH MEETING, MARCH 8, 1932

E. K. PLYLER: *The Fundamental Unit of Energy.*

The quantum theory states that energy is absorbed or emitted in discrete amounts. The present theory states that all amounts of energy are multiples of a unit called the atomerg. It is shown that the continuous spectrum is made of a large number of lines very close together. The present theory is shown to be in accord with the quantum theory of Planck and special relativity. The present theory indicates that light is corpuscular rather than a wave and explains the apparent conflict between the two interpretations.

336TH MEETING, APRIL 12, 1932

C. D. BEERS: *Some Genetic Studies on the Protozoan Didinium.*

This study deals with the experimental production of a state of depression (lowered vitality) in pure lines of the ciliate *Didinium nasutum* by culture on a diet of starved paramecia and with the capacity of the animals to recover from this type of depression upon transfer to a diet of well-fed paramecia. Under the conditions of the experiment depression manifests itself in a marked decrease in the fission rate, in the production of structural abnormalities, and in the death of the animals after about forty generations of culture. Control lines cultured on well-fed paramecia show no decline.

When depressed didinia are transferred in the last stages of decline to a diet of well-fed paramecia, they show a strikingly rapid recovery. After twenty-four hours, or two generations of culture on well-fed paramecia, they are regularly dividing as fast as the control lines, and all symptoms of depression have disappeared. Hence, this type of depression, unlike other depressions induced by subjecting the animals to slightly injurious physical or chemical factors, is not inherited after the restoration of the depressed animals to adequate and normal contions of culture.

Certain of the abnormalities that appear in the depressed lines are of special interest in that they speak for the existence of a gradient in the intensity of the metabolic processes along the longitudinal axis.

C. E. RAY, JR.: *Drought Streamflow in North Carolina.*

By review of the streamflow and other records going back to 1889, an evaluation is made of the severe droughts of 1925–26 and 1930–31. Considering the whole state these two-year periods are found to be of about the same order of dryness, with the western part of the state most severely affected in 1925 and the eastern in 1930. The relative dryness of each year in the 43-year period is determined. The frequency of occurrence of drought periods is analyzed, and it is noted that in 43 years we have had 7 severe drought years.

Variation in streamflow as between different streams in the same and different regions is discussed and it is pointed out that among the factors responsible for this variation may be named precipitation, topography, character of soil and geologic formation. Attention is directed to the fact that because of these variations, it is impossible to determine characteristics of flow of individual streams except by extended continuous systematic observations such as those developed by stream gaging agencies.

The collection of streamflow records is stated to be the function of the governmental stream gaging agency; their interpretation the function of the scientific investigator; and their application to problems of water utilization the function of the engineer. Greater activity in all of these fields is called for by economic needs.

Streamflow and rainfall droughts are discussed as being always related occurrences but frequently separated as to time of occurrence.

For streamflow droughts it is pointed out that a satisfactory technical definition is lacking and a method of approach is suggested. First it is recognized that a streamflow drought may manifest either by a greatly depressed rate of flow lasting for a relatively short period of time, or by a less markedly decreased rate of flow, but lasting for a sufficient length of time as to create a condition of scarcity. Then a method is given for evaluating the condition of normal low flow and using this as a reference base for measuring deficiency of flow. Normal *low* flow usually is about 30% of average or normal flow and when streamflow becomes less than 30% of normal (average), it is of drought proportions.

337TH MEETING, MAY 10, 1932

ENGLISH BAGBY: *The Concept of "Center of Difficulty."*

In connection with the clinical study of a minor disorder of personality it may be discovered that an array of maladjusting traits have

had their origin in a worry reaction of very simple form. Under such circumstances, the process of worry constitutes a "center of difficulty."

In the examination of a particular case-history, it is found that the patient became worried about his health. Thereafter, his psychological development followed two chief lines: (A) toward a hypochondria through which he avoided all of the obligations of life, and (B) toward a make-shift solution of his original worry problem.

THORNDIKE SAVILLE: *The Great Floods of 1929 in North Carolina.* (Illustrated.)

The floods of September 30–October 10, 1929, on eastern rivers were either the largest or next to the largest of record. The cause of these floods, and in general of all the greatest floods in North Carolina, was heavy rainfall consequent upon the passage of a West Indian hurricane a few days after the water holding capacity of the soil had been filled by precipitation from a storm attending the passage of a normal low pressure area. The variation of precipitation about the hurricane track is shown, together with flood hydrographs made by recording gages at numerous points. Inconsistences in time of passage of flood crests and in form of hydrographs are explained.

The following officers were elected for the year 1932–1933.
President, E. T. Browne.
Vice-President, G. R. MacCarthy.
Permanent Secretary, J. M. Bell.
Recording Secretary and Treasurer, C. D. Beers.
Editorial Committee, W. C. Coker, H. V. Wilson, Otto Stuhlman.

OFFICERS OF THE MITCHELL SOCIETY FOR THE PERIOD 1929–1932

1929–1930
President, R. E. Coker
Vice-President, E. T. Browne
Permanent Secretary, J. M. Bell
Recording Secretary-Treasurer, G. R. MacCarthy
Editorial Committee, W. C. Coker, H. V. Wilson, Otto Stuhlman.

1930–1931
President, C. S. Mangum
Vice-President, John W. Lasley

Secretary-Treasurer, R. W. Bost
Other officers as above.

1931–1932

President, F. K. Cameron
Vice-President, K. H. Fussler
Secretary-Treasurer, R. W. Bost
Other officers as above.

WILLIAM WILLARD ASHE

William Willard Ashe, after a brief illness, passed away in Washington, D. C., on March 18, 1932. One of nine children, he was born in Raleigh, N. C., June 4, 1872, at the old family residence, Elmwood. This was a homestead of about five acres, in the center of which stood the large house of fourteen rooms. Around it were found the usual gardens and groves, quarters, and stables typical of the southern tradition before the Civil War. Here were many kinds of native and cultivated trees, shrubs, and fruits, an ideal refuge for a multitute of birds. Ashe was undoubtedly a congenital naturalist, but his surroundings throughout his youth were such as to strengthen and educate him to an unusual degree in the development of his natural talents. As a boy Willard was versatile, soon showing a distinct gift for drawing and an unusual facility with his hands in carpentering and other mechanical work. Elmwood is still occupied by his father, Captain Samuel Ashe, a veteran of the Civil War, and several other members of his immediate family. From the age of four to fifteen, Willard's most intimate friend and playmate was his younger brother Samuel, from whom we have gathered the following facts about his early life.[1]

Willard Ashe's education began at home under his mother, and great aunt. Three years at the Raleigh Male Academy prepared him to enter the University of North Carolina as a sophomore in Latin, mathematics, and English, but since he still lacked one credit, he chose the subject in which he was most interested and, with his aunt as teacher, he covered elementary botany so well in three summer months that upon standing his entrance examination he surprised Dr. J. A. Holmes, professor of geology and botany, with his knowledge of the subject. . . . . When no differences between plants were visible to the ordinary eye, Willard could often note distinctions at a glance. But after one year's study of plants he saw no particular future for himself in this subject and at Dr. Holmes' suggestion he took an advanced course in geology. Having done this he returned to his first love and in his last year at the State University spent most of his time in the study of botany. During his years as a college student Ashe spent all of his spare time including his vacations in the field in search of specimens. A few years after his graduation his

[1] The death of Samuel Ashe on July 28, 1932, was announced after this paper went to press.

collections had assumed such proportion that it became necessary for him to erect a two story building to house them.

At sometime during this period he became desirous of more diversified knowledge and for a short while studied medicine under Dr. W. I. Royster.

Ashe entered the University of North Carolina in 1888 and was graduated in 1891 with the degree of Bachelor of Literature. In June of the same year he was offered the position of assistant in charge of timber investigations by the State Geologist, Dr. J. A. Holmes, who had charge of the recently organized North Carolina Geological Survey. At the end of this first summer he entered Cornell University, graduating the following June (1892) with the degree of Master of Science. From that time on for seventeen years he was connected with the Geological Survey of the state, part of the time paid only by the state, at other times working on special problems for the United States Forest Service or conducting forestry investigations for private parties.

The summer of 1891 and the latter half of 1892 were devoted to examinations of the character and the distribution of the forests of the state, and it was at this time that he assisted in the collection of the timber exhibit for the Columbian Exposition which now is on display in the State Museum. This general examination continued through 1893 and the early part of 1894. It was at this time that he was associated with Mr. Gifford Pinchot in the field study and preparation of the N. C. Geol. Survey Bulletin No. 6, containing two studies, *The Timber Trees of North Carolina*, by Mr. Pinchot, and *The Forests of North Carolina*, by Mr. Ashe. This bulletin, issued in 1897, was one of the earliest and probably the best state treatise on its timber trees and forests produced by any state up to that time. It is now out of print.

Early in 1895 Mr. Ashe published as Bulletin No. 7 of the N. C. Geological Survey, *Forest Fires, Their Destructive Work, Causes, and Prevention.* This first treatise on the forest five evil embodied the observations and experiences of the author during his four years of travel and study of conditions all over the state. In this report he reviewed the few laws dealing with forest fires, and incorporated the opinions of leading people in many of the counties showing the seriousness of fire damage; however, no definite outline of any proposed legislation was given. This was reserved for later publication. (Specific laws for the protection and perpetuation of the forests of the state were urged and published in 1908.)

During the summer and autumn of 1898, through the coöperation

of the United States Department of Agriculture, Mr. Ashe started his detailed study of the growth of loblolly pine in eastern North Carolina which many years later (1915) resulted in the publication of N. C. Geol. and Econ. Survey Bulletin No. 24, *Loblolly or North Carolina Pine*. The principal points to be determined at first were the rate of growth and the yield of this species on different kinds of soil, especially on soils less adapted to agricultural use. In the initiation of this study Mr. Ashe was associated with Mr. A. K. Mlodziansky of the United States Division of Forestry. Of this bulletin, Mr. Austin Cary, logging engineer of the United States Forest Service, says: "This I look on as far and away the best work on any American timber tree, and remarkable as the achievement almost entirely of one man. Time and again I have myself gone to it with questions, and I do not remember that it ever failed to answer one. I really expect that 25 years from now it will be more highly appreciated than it ever yet has been."

During these years Mr. Ashe also devoted time to an investigation of the swamp lands of the state begun several years previously to determine the most practical methods of developing valuable forest growth on areas unsuitable for agriculture and to determine which of the lands might be developed for agricultural use. A study of overflow lands along our larger rivers was also made to find out whether these alluvial bottoms should be diked and cleared or managed permanently for timber production.

In the summers of 1900 and 1901 Mr. Ashe was associated with Mr. H. B. Ayers of the United States Geological Survey in an examination of the forest conditions of the Southern Appalachian Mountains. This examination was made at the joint expense and under the joint supervision of the United States Bureau of Forestry, the United States Geological Survey and the State Geological Survey. The report of this study was published in 1905 by the United States Geological Survey as Professional Paper No. 37, the *Southern Appalachian Forests*, by Ayers and Ashe. This report included basic information upon which was grounded the demand for the establishment of national forests in the Southern Appalachians. It was not, however, until ten years later that the United States law establishing these national forests was enacted by Congress.

During the first few years of the present century there seems to have been less forestry work done by the North Carolina Geological Survey than either before or after that period. While Mr. Ashe did considerable work, it seems that much of his time was paid for either in part or

entirely by the United States Bureau of Forestry. It was at this period that the State Geologist, Dr. J. A. Holmes, devoted so much of his time and effort to securing National Forest Reserves in the Southern Appalachians. This campaign, begun in North Carolina in 1900, did not succeed until the Weeks law was passed in 1911. In other words, ten years of unremitting effort was necessary to bring about this conservation measure which has meant so much to the whole country.

The studies of the swamp lands and of the growth of loblolly pine were continued, but no published results were made available until an increase in the state appropriation made more intensive forestry efforts possible. In the meantime in 1905 the Geological Survey was reorganized by legislative enactment with an enlargement of the name into the State Geological and Economic Survey. Dr. Holmes resigned as State Geologist and Dr. Joseph Hyde Pratt, for many years Mineralogist of the Survey, was made State Geologist and Director of the Survey. It was not until the legislature of 1907 that an increase in appropriation made it possible for the Director to offer Mr. Ashe a full-time permanent position as Forester of the Survey, which he accepted.

The next two years were busy ones for Mr. Ashe. A coöperative agreement was entered into between the Survey and the State Board of Education for the careful study of all of the public lands belonging to the Board, it contributing to the cost $1500.00 over a two year period. Reports were made directly to the Board, but only two very brief reports were published. The sum of the results might, it is thought, be expressed briefly in the statement that there was very little land remaining in the hands of the Department of Education of value for the timber upon it or for expected growth, previous sales having alienated the more valuable areas. The lands were difficult to locate and in many cases the titles were contested by squatters or adjacent land owners. The policy of the Department therefore to sell the lands after offers were made for them seems to have been continued as before.

During these last two years of Mr. Ashe's connection with the forestry work of his native state, he not only accomplished a large amount of field work, but he prepared and published Bulletin No. 16, *Shade Trees of North Carolina*, and Bulletin No. 17, *Terracing of Farm Lands*. These were both published in 1908. The former is still the standard book for highway and home tree planting in North Carolina, the latter was one of the earliest pleas to the farmers of the state to control erosion.

His last publication by the North Carolina Geological and Economic Survey was Bulletin No. 24, on Loblolly Pine referred to above. While

all the field work and practically all the editing was done while he was connected with the Survey, the finishing touches were given to it and it was published by the Survey after Mr. Ashe's resignation in May, 1909. His resignation terminated a connection of eighteen years as the first forester employed by the State of North Carolina. Throughout this long period, nearly half of his professional life, he had been advocating in every possible way protection and better management of the forest lands of the state. In conferences with and reports to land-owners, through the press, in lectures, and in his official bulletins, he urged the business necessity of forest fire prevention. His last major effort was to try to convince the General Assembly of 1909 that laws to prevent forest fires and to definitely establish a Division of Forestry should be enacted at once. This was not done, however, until six years later.

Ashe, who in previous years had carried out a number of temporary assignments for the U. S. Forest Service, was from now on permanently employed by the Federal Government. First as Forest Assistant he was assigned to coöperative work with landowners, examining timber tracts and advising lumbermen in the handling of their forest properties. Later he became Secretary of the National Forest Reservation Commission and was attached to the office of Acquisition as Forest Inspector and later as Assistant District Forester. His duties were to examine forest tracts and secure offers from the owners for areas to be added by purchase to the eastern national forests. In 1928 Mr. John E. Burch became Secretary of the Reservation Commission and Ashe, with the title of Inspector, devoted his whole time to the more difficult duties of examining and appraising forest lands.

Mr. E. A. Sherman, Associate Forester of the U. S. Forest Service, who had general supervision of Ashe's official activities gives the following estimate of his work for the Federal Government.

"During the past 18 years I learned to rate Ashe as the best judge of values of timber and timberlands east of the Mississippi. I also learned to appreciate his work in the field of research. Always charged with man-sized administrative jobs, he nevertheless made a number of important contributions to economic progress. He was a pioneer in advocating the terracing of farm lands in North Carolina; he demonstrated to the lumbermen that they were losing money by cutting small trees; and he analyzed the financial limitations of protecting reservoir capacity from loss by silting.

"His knowledge of timber and timberland values was uncanny. More than once I have seen 'Acquisition men' almost in tears because Ashe

had recommended against the purchase of some particularly desirable tract at a price which he believed to be too high, although the examiner considered it a bargain at that price and believed the Service, in rejecting it, would be overlooking an opportunity it never would have again. Nearly always Ashe's judgment was vindicated by the owner sooner or later accepting the price which Ashe had indicated as representing the fair going value of the property under existing market conditions. Of course, he was not absolutely infallible, but nearly always he was right. We all grew to accept his judgment as final. In all the years past I never once recommended the purchase of a tract of land at a cent higher than Mr. Ashe indicated.

"Looking back over the years, and considering Ashe's contribution to research, it is a matter of personal regret that so much of his time was occupied on what might be termed administrative jobs. The truth is he could save the Government so much money in our purchase negotiations that the temptation to use him on this work was irresistible. To say that he saved the Government on the average annually not less than one hundred thousand dollars in each outlay on individual purchases and by the establishment of reasonable price levels for land, would not, in my judgment, be an over-estimate. And yet his little leaflet entitled 'Small Trees Wasteful to Cut For Saw Timber' doubtless saves the lumber industry annually throughout the country many times this amount, in addition to leaving the cut-over lands in better condition for future timber crops. But the loss to the Forest Service and to forestry in America resulting from the death of Ashe cannot be measured in dollars and cents."

Throughout his life Mr. Ashe maintained a keen interest in systematic botany. His remarkably acute perception of form and detail led him to distinguish variations whenever he met them and he was never satisfied until he had put these observations on record. Mr. William A. Dayton of the U. S. Forest Service has been kind enough to give us the following brief sketch of Mr. Ashe as a systematic botanist.

"Although his botanizings were conducted chiefly on his own time or, if in connection with his official duties, necessarily as a sideline, Ashe was an indefatigable observer, collector, and annotator of plants. Few, if any, were his equals in first-hand knowledge of the flora and vegetative types of the southeastern states, more especially of the woody plants and of the less accessible areas. His eye was exceedingly acute to detect differences and, while his specific concept did not always suit the more conservative, numerous of his species and varieties undoubtedly will

survive the inevitable sifting process of critical review. In all Ashe published 510 new botanical names, including 177 in *Crataegus*, 60 in *Hicoria* (syn. *Carya*), 47 in *Panicum*, 43 in *Quercus*, 33 in *Azalea* (syn. *Tsutsusi*), 24 in *Polycodium*, 15 in *Castanea*, and 13 each in *Robinia* and *Tilia*. While the critical reviewer may perhaps regret a certain amount of nomenclatural vacillation in his work yet the fair-minded cannot withhold whole-hearted admiration and astonishment at the extraordinary energy, industry, and prolificacy of this man who, in those spare moments spent by so many profitlessly, produced a richer harvest of published results than many of us seem able to achieve from years of routine toil.

"Six trees and two shrubs of the Southeast, besides one widely distributed grass of the eastern states, perpetuate his name: *Castanea ashei* Sudw., *Crataegus ashei* Beadle, *Hicoria ashei* Sudw., *Juniperus ashei* Buchholz, *Magnolia ashei* Weatherby, *Panicum ashei* Pearson, *Polycodium ashei* Harbison, *Quercus ashei* Trel.,[2] and *Schmaltzia ashei* Small.

"Ashe was appointed a member of the Forest Service Tree Name Committee in 1928 and served as chairman of it from 1930 to his death. He was a prolific writer, and published upwards of 166 scientific papers. He prepared the *Robinia* chapter of the second edition of Small's *Flora of the Southeastern United States* and the oak portion of *Standardized Plant Names*. In a bibliography of Ashe's published papers prepared by the writer 54 titles are in dendrology and other phases of systematic botany, 9 concern ecological subjects—chiefly forest types—, 3 papers deal with English plant nomenclature, and 2 papers are on floristics (lists of trees and shrubs).

"The very extensive private herbarium of Mr. Ashe is housed in part at Raleigh, N. C., and in part in his residence in Washington, D. C. Presumably it contains his type material. It is unfortunate, from the standpoint of botanical science that a set of these types, or isotypes, is not on file in the U. S. National Herbarium or some other suitable repository. Hitchcock and Chase, in their treatment of the genus *Panicum* (Contrib. U. S. Natl. Herb. **15**: 2. 1910) have hinted at the

[2] This is a Georgia hybrid, published in 1917, of *Q. laevis* Walt. and *Q. cinerea* Michx. Unfortunately there is also a Louisianan *Q. ashei* Sterrett (published in 1922), obviously a homonym and untenable, which is a synonym of *Q. similis* Ashe = *Q. stellata similis* (Ashe) Sudw. Confusion was further increased by Sudworth's publication of a *Q. marilandica ashei* in 1922, which Trelease intimates is a starved form of *Q. marilandica* Muench. occurring from central Texas to Kansas.

handicap they were under in monographing this largest and most difficult of American grass genera by the inaccessibility of Ashe's types. This situation, the writer hopes, may some day be corrected not only for the sake of American plant taxonomy but in protection of the scientific labors of a distinguished forester and high-minded southern gentleman."

In concluding this brief and inadequate account of the remarkably active and productive life of Mr. Ashe, the committee is glad to report that a much fuller study of his life, works, and character is contemplated by Mr. W. R. Mattoon, Extension Forester, U. S. Forest Service, and that a complete bibliography of his publications has been prepared by Mr. William A. Dayton, U. S. Forest Service, which it is hoped will be published before too long a time. In the death of Mr. Ashe, our Academy has lost one of its ablest and most valued members. He was a charter member of the Academy, and it is particularly fitting that we should do him honor. We will not attempt to give any adequate estimate of his personal character and social virtues. From many sources we have received spontaneous expressions of the regard and affection in which he was held by all who knew him. He was a man of transparent honesty, unselfish devotion to duty, happy and cheerful in his own work, and always appreciative of the work of others. In his death both science and humanity have suffered a profound loss.

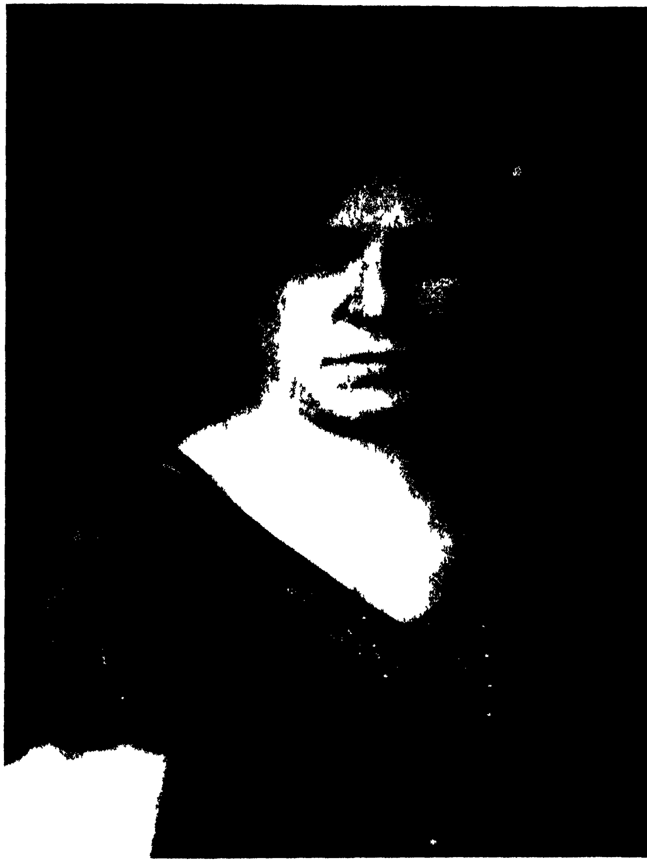
W. C. COKER,
J. S. HOLMES,
C. F. KORSTIAN,
Committee from the North Carolina Academy of Science.

MARY FRANCES SEYMOUR

Early in the morning of March 3, 1932, as a result of a stroke of paralysis, Mary Frances Seymour passed peacefully away in the Salisbury General Hospital, having taught her regular schedule of classes the day before.

Miss Seymour was born and reared at Winsted, Connecticut. In 1898 she was graduated from Mount Holyoke College with the B.A. degree, and for several years taught botany and biology in the high schools in New England or in the vicinity of New York. Specializing in physiology, she was awarded the M.A. degree by the Teachers College of Columbia University in 1916, and that fall was elected to the teaching staff of the North Carolina College for Women, Greensboro, with the rank of instructor. The following summer she pursued graduate work at Harvard University, while a later season was spent in study at the University of Chicago. She was soon promoted to the rank of associate professor, and during the year 1919–20 became acting head of the Department of Biology. Her duties at this institution continued until 1923, at which time she requested leave of absence in order to be closer to her parents who were then in declining health. Work in her chosen field was pursued the following year at Yale University. In 1925, when Catawba College was enlarged and removed from Newton to Salisbury, Miss Seymour became responsible for the work of the Department of Biology, which she built up from a meager beginning to its present position.

Miss Seymour is remembered as a conscientious, sympathetic, capable teacher, ever holding to high ideals herself and constantly by precept and practice inspiring in her students intellectual endeavor. She was quite unselfish in the giving of her time and her talents to her students and especially so to the one in need of friendy understanding. While her teaching was permeated with a sense of reverence before the mystery and beauty of nature, she at the same time always gave enthusiastic encouragement to research. Miss Seymour was an organizer of unusual ability. At the North Carolina College for Women she initiated courses of her own planning in hygiene, courses which are continued there at the present time with enhanced value. Her work at Catawba in or-



MARY FRANCES SEYMOUR

ganizing similar courses, and also courses in bacteriology, bids fair to be equally lasting. Although she produced but few learned papers, her scholarship is evidenced by a fellowship in the American Association for the Advancement of Science, a distinction held by very few women in North Carolina. Her membership in the North Carolina Academy of Science began in 1917, her first year in this state. When warned six months prior to her death that unless she relinquished some of her work her life would be endangered she replied, in effect, that work was her joy and her life. She continued in her duties with her whole energy and died, as she had wished, in the midst of her task. Miss Seymour leaves two sisters and a brother: Mrs. Guy E. Hood, Schenectady, N. Y.; Mrs. Beatrice Wilson, Evansville, Indiana; and Mr. Edward Seymour, Hutchinson, Kansas.

M. L. BRAUN, Catawba College,
H. B. ARBUCKLE, Davidson College,
J. P. GIVLER, North Carolina College,
Committee from the North Caroli a Academy of Science.

ON A COLLECTION OF FISHES FROM THE TUCKASEEGEE AND UPPER CATAWBA RIVER BASINS, N. C., WITH A DESCRIPTION OF A NEW DARTER[1]

By SAMUEL F. HILDEBRAND, U. S. Bureau of Fisheries

PLATE 3 AND 2 TEXT FIGURES

INTRODUCTION

During the summer of 1930 Dr. James S. Gutsell of the Bureau of Fisheries, upon the request of the North Carolina Department of Conservation, made a study of the effects upon aquatic life, and fishes in particular, of certain trade wastes discharged into streams of the western part of North Carolina. Three factories, a tannery, a tannery extract plant, and a paper-board factory, are located in close proximity at Sylva, and all discharge their wastes into Scotts Creek, about two miles from its juncture with the Tuckaseegee River at Dillsboro. A tannery and a plant for the manufacture of tannery extract are situated on the Catawba River at Old Fort. Doctor Gutsell collected the fishes upon which this report is based during his investigation pertaining to the trade wastes. In addition to the specimens from the mountain streams of the western part of the state, Dr. R. E. Coker of the University of North Carolina submitted a small collection mostly made in creeks in the vicinity of Chapel Hill. The specimens from Chapel Hill (being from the Cape Fear River drainage) are not listed, but some of the species studied are mentioned in this paper wherever comparisons are made with the Catawba and Tuckaseegee River specimens.

The fishes of the mountain streams of North Carolina are known principally from collections reported upon by Cope in 1870 and by Jordan in 1889. The present collection is of special interest, because it was made in regions in which the fish fauna is very imperfectly known. The collecting done in connection with the previously mentioned pollution studies was not extensive enough, nor were the methods employed varied enough, to make the collections exhaustive. Small collecting seines only were used and Doctor Gutsell estimates that only about 6 hours were spent at seining in the Catawba and probably about 50 hours in

[1] Published by permission of the U. S. Commissioner of Fisheries.

the Tuckaseegee. Consequently, several species recorded from the general vicinities in which the collections were made are not represented. However, several little known species and one apparently undescribed darter are included.

The writer has had for comparison several types deposited in the National Museum, as well as other specimens in the museum and Bureau of Fisheries collections. It has been possible, therefore, to determine definitely the diagnostic characters for several little known species, and a special effort was made to point out such characters in the present paper.

Doctor Gutsell has prepared a special report (unpublished) dealing with the effects of the trade wastes upon the aquatic life. In general, the pollutions do not appear to have been such at the time of the investigation that fish were killed out-right in the streams. However, such bottom dwelling species as the suckers and darters were very few or missing in the streams for some distance below the source of pollution. Their absence may have been due to an unfavorable feeding ground rather than to a dislike for the pollution, as a rather heavy sediment was deposited on the bottom from the trade wastes. Such sediments provide a decidedly unfavorable environment for many insects and other bottom dwelling forms, which enter into the food of suckers and darters. Therefore, the bottom feeding fishes may have been absent because food was missing, rather than because of a direct deleterious effect of the pollution on the fish themselves.

In general, the writer has accepted the genera recognized in the Check List of the Fishes and Fishlike Vertebrates of North and Middle America north of the northern Boundary of Venezuela and Colombia" by Jordan, Evermann, and Clark.[2] However, in some instances, particularly with respect to the divisions within the old genus Notropis, the supposed generic distinctions do not appear to be well founded. Therefore, the names elevated from subgeneric to generic rank in the check list already mentioned are not always recognized.

Family PETROMYZONTIDAE

1. ICHTHYOMYZON CONCOLOR (Kirtland)

Silvery lamprey

Ammocoetes concolor Kirtland. Bost. Jour. Nat. Hist., III, 1840, p. 373, with plate (larva). Mahoning River; Scioto River.

[2] Report U. S. Commissioner of Fisheries for 1928 (1930), part II, pp. 1 to 670. Washington.

Three larval specimens (Ammocoetes) of uniform length, namely 70 mm., probably belong to this species. The mouth remains horseshoe-shaped and the teeth and eyes are quite rudimentary. About 53 muscular rings surround the body between the last gill opening and the vent. The buccal disk probably will be large; the dorsal fin is very low, without an evident notch, and it is continuous with the anal fin around the tail. The preserved specimens are quite pale brown, with the caudal portion of body margined below the base of the dorsal and anal with dark brown. Slight indications of a dark spot above each gill opening are present.

This species of lamprey, which according to Jordan (Manual of Vertebrate Animals, p. 7, 1929) ranges from Lake Erie to Louisiana and northward to Hudson Bay, has not been recorded from North Carolina. The specimens at hand were seined in the Tuckaseegee River near the Cullowhee bridge.

Family AMEIURIDAE

2. ICTALURUS PUNCTATUS (Rafinesque)

Channel catfish

Silurus punctatus Rafinesque. Amer. Month. Mag., II, 1818, p. 359. Ohio River.

A single specimen, 260 mm. long, of this common and widely distributed species of the Gulf drainage, the Mississippi Valley and Great Lakes region, was taken in the Tuckaseegee River near Wilmot. It was recorded from the French Broad and other tributaries of the Tennessee River in North Carolina by Cope in 1870. It was again reported from the French Broad by Jordan in 1889. Since the young were not taken in about 50 hours collecting with small collecting seines, the species probably is not common in the Tuckaseegee River.

The following proportions and fin ray counts are based on the specimen at hand. Head, 4.06; depth, 5.15 in head. Eye, 5.5; snout, 2.5; interorbital, 2.6; pectoral spine, 1.65 in head. D. I, 7; A. 24.

3. LEPTOPS OLIVARIS (Rafinesque)

Yellow catfish; Mud cat

Silurus olivaris Rafinesque. Amer. Month. Mag., II, 1818, p. 355. Ohio River.

This catfish of the Gulf States and the Mississippi basin, is represented by a single specimen 600 mm. long, taken in the Tuckaseegee

River at Ela. The species very probably is not numerous in the Tuckaseegee River since the young were not taken in rather extensive collecting with small collecting seines. The young of the yellow cat were reported as not uncommon in the channels of the French Broad River at Hot Springs and the South Fork of the Swannanoa River near Black Mountain by Jordan in 1889.

The following proportions and fin ray counts are based on the specimen at hand. Head, 3.3; depth, 5.55 in length. Eye, 15.0; snout, 3.3; interorbital, 2.5 in head. D. I, 7; A. 15.

4. SCHILBEODES INSIGNIS (Richardson)

Mad-tom

Pimelodus insigne Richardson. Fauna Bor.-Amer., III, 1836, p. 32. Type locality not known.

A single specimen, 50 mm. long, of this mad-tom, which is reported to reach a length of one foot, was taken in the Catawba River near Old Fort. This species, according to Smith (Fishes of North Carolina, 1907), inhabits streams on the eastern slope of the Alleghany Mountains from Pennsylvania to South Carolina. In North Carolina it has been reported from the Tar, Neuse, Yadkin, Catawba, and Cape Fear Rivers.

The following proportions and counts are based on the specimen at hand. Head, 3.8; depth, 5.7 in standard length. Eye, 5.25; snout, 2.35; interorbital, 3.0; pectoral spine, 2.6; caudal peduncle, 1.9 in head. D. I., 6; A. 18 (including rudiments).

5. AMEIURUS PLATYCEPHALUS (GIRARD)

Mud catfish; Brown catfish

Pimelodus platycephalus Girard. Proc. Acad. Nat. Sci. Phila., II, 1859 (1860), p. 161. Anderson, S. C.

This species is represented by a single small specimen, 45 mm. long, taken in the Catawba River about four miles below Old Fort. This fish is recognized largely by the emarginate caudal fin and the short anal, which has only 18 rays (rudiments included) in the specimen at hand. This catfish is restricted in its range to the streams from the Cape Fear to the Chattahoochee. Jordan found it abundant in the Catawba near Marion in 1889.

The following proportions and counts are based on the small specimen at hand. Head, 3.65; depth, 4.9 in standard length. Eye, 4.05; snout, 2.3; interorbital, 2.65; pectoral spine, 2.05; caudal peduncle, 2.3 in head. D. I, 6; A. 18.

Family CATOSTOMIDAE

6. HYPENTELIUM NIGRICANS (Le Sueur)

Stone-roller; Black sucker; Hog sucker

Catostomus nigricans Le Sueur. Jour. Acad. Nat. Sci. Phila., I, 1817, p. 102. Lake Erie.

This species is represented in the present collection by one specimen 95 millimeters long from the Catawba River at Old Fort, by 107 specimens, varying in length from 45 to 275 millimeters from the Tuckaseegee River at Dillsboro, Ela, Cullowhee, Laporte and Bryson City, and by 2 specimens, 50 and 90 millimeters long, from the Ocono Lufty River near the Cherokee Indian School.

This widely distributed sucker, ranging from New York to Minnesota, southward to Arkansas and South Carolina, reported as common on both sides of the Alleghanies in North Carolina, evidently is rather numerous on the west side of the divide in the Tuckaseegee River and its tributaries between Dillsboro and Bryson City, except for several miles below the discharge of trade wastes from factories located on Scotts Creek at Sylva. However, the fact that only one small specimen was secured in about 6 hours seining indicates that the species probably is rather rare in the Catawba River and its tributaries in the vicinity of Old Fort.

The following proportions and counts are based on 11 specimens, ranging in length from 45 to 220 millimeters. Head, 3.6 to 4.75; depth, 4.75 to 5.4 in standard length. Eye, 4.0 to 5.0; snout, 1.8 to 2.7; interorbital, 2.4 to 3.25; pectoral 1.0 to 1.3; caudal peduncle, 2.95 to 3.4 in head. D. I, 10 to 12; A. I, 7 or 8; scales 48 to 53.

7. CATOSTOMUS COMMERSONII (Lacépède)

Common sucker; Sand sucker; White sucker

Cyprinus commersonii Lacépède. Hist. Nat. Poiss., V, 1803, p. 502. Type locality unknown.

This widely distributed sucker, ranging from Quebec and New England to Montana and Colorado southward to Missouri and Georgia, is represented in the present collection by a single specimen, 160 millimeters long. This fish was taken in the Catawba River near Old Fort and up-stream from the entrance of the waste from a tannery and a plant for the manufacture of tannery extract. This sucker evidently is not common now in this vicinity, although Jordan found it so in 1889

near Marion, a city not far from Old Fort. Although this species has been taken in the upper tributaries of the Tennessee (French Broad, Cane, and Swannanoa Rivers), it was not taken in the Tuckaseegee.

The following proportions and counts are based on the specimen at hand. Head, 4.2; depth, 4.6 in standard length. Eye, 5.2; snout, 2.2; interorbital, 2.6; pectoral, 1.15; caudal peduncle, 2.4 in head. D. I, 13; A. I, 8; scales, 68.

8. MOXOSTOMA AUREOLUM (Le Sueur)

Red-horse; White sucker

Catostomus aureolus Le Sueur. Jour. Acad. Nat. Sci. Phila., I, 1817, p. 95. Lake Erie.

This common sucker, ranging from Lake Ontario and Lake Michigan southward to Arkansas and Georgia, is known in North Carolina only west of the Alleghanies. The young are common in the Tuckaseegee River, between Dillsboro and Bryson City. The collection contains 93 specimens, ranging in length from 45 to 140 millimeters taken as follows: Tuckaseegee River at Dillsboro, East Laporte, Cullowhee, and Bryson City, and the Ocono Lufty River near the Cherokee Indian School.

The following proportions and counts are based on 9 specimens, ranging in length from 45 to 140 millimeters. Head, 3.45 to 4.2; depth, 4.2 to 4.95 in standard length. Eye, 3.6 to 5.0; snout, 2.25 to 3.1; interorbital, 1.85 to 3.3; pectoral, 1.1 to 1.6; caudal peduncle, 2.45 to 3.0 in head. D. I, 12 or 13; A. I, 7 or 8; scales, 47 to 50.

Family CYPRINIDAE

9. CAMPOSTOMA ANOMALUM (Rafinesque)

Stone-roller

Rutilus anomalus Rafinesque. Ichth. Ohiensis, 1820, p. 52. Licking River, Kentucky.

The stone-roller is represented by 5 specimens in the present collection which range in length from 60 to 110 millimeters. These specimens are from the Catawba River near Old Fort. This widely distributed species, known from Central New York to Tennessee, Wyoming, and Texas, although reported as common in some of the upper tributaries of the Tennessee River, was not taken in the Tuckaseegee.

The stone-roller is readily recognized by its long intestine, which is coiled around the air bladder, and by the black peritoneum.

The following proportions and counts are based on the specimens in the present collection. Head 4.1 to 4.6; depth 4.0 to 4.85 in standard length. Eye 4.0 to 4.8; snout 2.35 to 2.8; interorbital 2.7 to 3.4; pectoral 1.1 to 1.2; caudal peduncle 1.7 to 2.1 in head. D. II, 8; A. II, 7; scales 8–49 to 52–6, 18 to 22 before dorsal.

10. CLINOSTOMUS VANDOISULUS (Cuvier and Valenciennes)

Dace

Leuciscus vandoisulus Cuvier and Valenciennes. Hist. Nat. Poiss., XVII, 1844, p. 317. South Carolina.

This dace, long assigned to the old-world genus Leuciscus under which it was first described, is here placed under Clinostomus, following the check list of Jordan, Evermann, and Clark (p. 121).[3] It ranges from Maryland to Georgia on both sides of the Alleghany Mountains and is represented by 2 specimens, 80 and 92 millimeters long, from Deep Creek, tributary of the Tuckaseegee River at Bryson City, and by 14 specimens ranging from 30 to 52 millimeters in length, from the Catawba River at Old Fort.

The specimens from the Tuckaseegee basin are much darker than the ones from the Catawba. Furthermore, the former are spotted with irregular dark spots of various sizes and a dark lateral band is evident only on the caudal peduncle. In life the sides were largely bright red. A well defined dark lateral band, extending from the eye to the base of the caudal, and a vertebral streak are present in Catawba specimens, which are entirely unspotted. No structural differences are evident between Tuckaseegee and Catawba specimens, and the differences in color probably are largely due to age, the Tuckaseegee specimens being much larger than the others.

The following proportions and counts are based on 6 specimens, 2 from the Tuckaseegee and 4 from the Catawba, having a range in length of 31 to 90 millimeters. Head 3.4 to 3.9; depth 4.35 to 4.8 in standard length. Eye 3.0 to 3.45; snout 3.2 to 4.0; interorbital 3.0 to 3.7; pectoral 1.3 to 1.6; caudal peduncle 2.5 to 3.0 in head. D. I, 8 or 9; A. I, 9 to 11; scales 51 to 54; pharyngeal teeth 2,4–4,2 and 1,5–4,2 (two specimens counted).

[3] Rept. U. S. Com. Fish, Pt. II, 1928 (1930), 670 pp.

11. SEMOTILUS ATROMACULATUS (*Mitchill*)

Horned dace

Cyprinus atromaculatus Mitchill. Amer. Month. Mag. II, 1818, p. 324. Wallkill River, N. Y.

This widely distributed species, ranging from Maine to Alabama and Westward to Missouri and Wyoming, is represented by 4 specimens in the present collection. A single small specimen, 27 millimeters long, was taken in a side run of the Catawba River and 3 specimens, respectively, 75, 115, and 115 millimeters long, are from creeks at Chapel Hill. The species was not seen in the Tuckaseegee basin.

The specimens apparently have rather larger scales than representatives from Illinois and probably are referable to the variety *thoreauianus* of Jordan, originally described from the Flint River, Georgia. The small specimen from Old Fort has a distinct, but narrow, dark lateral band and a black caudal spot. The large specimens from Chapel Hill have no lateral band. However, the 75 millimeter specimen still has an indication of a band. The characteristic dark spot at the base of the anterior rays of the dorsal, always present in the adult, is not evident in the 27 millimeter fish. A slight indication of a barbel over the posterior end of the maxillary is discernible under considerable magnification in the smallest specimen, while in the larger ones it is nearly half as long as pupil.

The following proportions and counts are based on the specimens in the present collection. Head 3.65 to 4.05; depth 4.35 to 4.9 in standard length. Eye 3.15 to 5.2; snout 2.9 to 3.7; pectoral 1.5 to 1.9; caudal peduncle 2.15 to 2.5 in head. D. I, 8; A. I, 8 or 9; scales 10–52 to 56–5, 25 to 27 before dorsal.

12. RHINICHTHYS CATARACTAE (Cuvier and Valenciennes)

Long-nosed dace

Gobio cataractae Cuvier and Valenciennes. Hist. Nat. Poiss., XVI, 1842, p. 315. Niagara Falls, New York.

The long-nosed dace, ranging from New England to North Carolina and to Wisconsin, is represented in the present collection by 4 specimens, ranging in length from 40 to 62 millimeters, all taken near Dillsboro. Three of these specimens were caught near the mouth of Camp Creek and the other one in the Tuckaseegee River. The related species, *R. atronasus* also reported from the upper waters of the Tennessee basin, was not taken.

The following proportions and scale and fin ray counts are based on 3 specimens, ranging from 56 to 62 millimeters in length. Head 3.55 to 3.8; depth 5.05 to 5.43 in standard length. Eye 4.75 to 4.8; snout 2.1 to 2.3; pectoral 1.22 to 1.26; caudal peduncle 2.1 to 2.2 in head. D. I, 8; A. I, 7; scales 65 to 76.

13. PHENACOBIUS URANOPS Cope

Phenacobius uranops Cope. Proc. Acad. Nat. Sci. Phila., XIX, 1867, p. 96. Holston River, Saltville, Virginia.

This species, known only from the basin of the upper Tennessee, is represented by 11 specimens, ranging in length from 45 to 62 millimeters, all taken in the Tuckaseegee River, partly at Dillsboro and partly at Cullowhee.

The roundish body, somewhat depressed head, long blunt snout, the inferior mouth with the thickened plicated upper lip, give this fish a strikingly sucker-like appearance. The often repeated statement, namely that the species of this genus have laterally enlarged lobes on the lower jaw, appears rather misleading to the present writer, as the "lobes" are only a continuation of the thick plicated upper lip, recurving slightly at the angle of the mouth without a definite demarcation at the angle. Specimens with the mouth wide open show most clearly the continuation of the fleshy upper lip and in such specimens no lobes are evident on the lower jaw, which appears thin and horny. The writer is prompted to make this explanation especially because of the difficulty he once experienced, when a beginner, with specimens which had the mouths wide open.

This species is described currently as having the chest and abdomen naked in advance of the ventral fins. In two specimens in the present collection the chest and abdomen are fully scaled. In the others the anterior part of the chest, that is, from below the base of the pectorals forward, is naked, showing that there is variation. The scales are strikingly small in advance of the dorsal (about 25 rows crossing the back between the head and origin of dorsal), becoming larger posteriorly.

The following proportions and counts are based on 4 specimens ranging in length from 50 to 56 millimeters. Head 4.3 to 4.6; depth 5.25 to 6.4 in standard length. Eye 2.9 to 3.6; snout 2.0 to 2.5; pectoral 1.2 to 1.3, caudal peduncle 2.3 to 2.5 in head. D. II, 8; A. 7 or 8; scales 60 to 63.

14. NOCOMIS KENTUCKIENSIS (Rafinesque)

Horny-head: River chub

Luxilus kentuckiensis Rafinesque. Ichth. Ohiensis, 1820, p. 48. Ohio River.

The river chub, ranging on both sides of the Alleghanies from Pennsylvania to Alabama and to Wyoming, is represented by about 140 specimens, varying in length from 35 to 210 millimeters, taken in the Tuckaseegee River at Wilmot, Ela, Dillsboro, Cullowhee, and Bryson City, and in the Ocono Lufty River near the Cherokee Indian School.

The specimens in the present collection are quite chubby and roundish; the mouth is slightly oblique and inferior; the snout is scarcely in advance of the upper jaw; the maxillary fails to reach opposite the eye, except in young about 60 millimeters and less in length. The preorbital has been described[4] as much wider than eye. This is true only in the larger fish. In specimens about 80 millimeters long the preorbital and the eye are about equal in width and in specimens of about 50 millimeters and less the preorbital is narrower than the eye. The origin of the dorsal is almost directly over the insertion of the ventrals. Since the specimens were taken during August and September (between breeding seasons), nuptial tubercles and swellings are not prominent.

A rather definite dark bar is present behind the margin of the opercle, and specimens of about 100 millimeters and less in length have a dark lateral band which is most distinct in the very young which also have a more or less definite black spot at the base of the caudal.

The following proportions and counts are based on 7 specimens ranging in length from 43 to 153 millimeters. Head 3.7 to 4.35; depth 3.95 to 5.0 in standard length. Eye 3.2 to 4.45; snout 2.25 to 3.2; maxillary 3.2 to 3.56; preorbital 3.75 to 4.25; pectoral 1.35 to 1.63; caudal peduncle 2.15 to 2.4 in head. D. I or II, 8; A. I or II, 7. (In large specimens a short undivided ray precedes a longer and larger one in both the dorsal and anal. This ray although probably present, is not very evident in small specimens.) Scales 6 or 7—39 to 42—5, 16 to 18 before dorsal; pharyngeal teeth 4–4.

15. NOCOMIS HYPSINOTUS (Cope)

High-backed minnow

Cerathichthys hypsinotus Cope. Proc. Amer. Phil. Soc., XI, 1870, p. 458. Upper Catawba and Yadkin Rivers, North Carolina.

[4] Hubbs, Univ. Mich. Mus. Zool., Misc. Pub. 15, 1926, p. 24.

This minnow, known only from the Santee Basin in North and South Carolina, is represented by 89 specimens from the (type locality) Catawba River and tributaries near Old Fort which range in length from 27 to 130 millimeters. There are also at hand 9 specimens from Chapel Hill, ranging in length from 50 to 158 millimeters, which appear to belong to the present species. The smaller specimens agree well with Cope's description of the type based on a specimen about 70 millimeters in length.

While a few recent authors have regarded the present species as a representative of a different genus (Erinemus) from the preceding one, *Nocomis kentuckiensis*, the present writer does not regard the division justifiable for reasons which will become evident from the discussion in subsequent paragraphs. Therefore, the two species of the old genus Hybopsis herein are referred to one and the same genus, namely Nocomis. The two species in question, as well as several others, formerly were placed under Hybopsis. However, the name, Hybopsis, is regarded as not available for this group by recent authors. The next oldest name that is available is Nocomis. The preceding species, *kentuckiensis*, has been referred to that genus in some of the current works and *hypsinotus* now also is referred to the same genus.

A careful examination of specimens shows that *kentuckiensis* and *hypsinotus* really are quite closely related. The mouth in *hypsinotus* is only slightly more inferior than in *kentuckiensis*, a difference almost imperceptible in some specimens. More evident differences are the rather broader and more strongly decurved snout and more nearly horizontal mouth in *hypsinotus*. The width of the preorbital varies greatly with age, and the difference is slight, being evident only when specimens of about the same size are compared. For example, in two specimens, each about 115 millimeters in length, the preorbital is contained in the head 3.5 times in *kentuckiensis* and 4.0 times in *hypsinotus*. In two specimens, each 95 millimeters long, the preorbital is contained in the head 3.8 times in *kentuckiensis*, and 4.15 in *hypsinotus*. In series of various sizes the measurements overlap, as shown by the proportions given in the last paragraph of the discussions of each species.

In comparing specimens of the same size it becomes evident that *hypsinotus* has a slightly smaller eye than *kentuckiensis*, a difference that is not evident from measurements based on a series of specimens of various sizes. In two specimens. each about 115 millimeters in length, the eye is contained in the head 5.1 times in *hypsinotus* and 4.3 times in *kentuckiensis*. Similarly in two specimens, each about 95 millimeters

long, the eye is contained in the head 4.7 times in *hypsinotus* and 3.2 times in *kentuckiensis*. Furthermore, the body is somewhat more compressed in *hypsinotus*, the width at midlength of the pectorals being about equal to the depth of the head at orbits, whereas the width of the body measured in the same way in *kentuckiensis* is about equal to the depth of the head at the preopercular margins.

The pharyngeal teeth, according to published descriptions, sometimes are in two rows in both species. However, in 7 specimens of each species examined these teeth constantly were in one row. The larger males of *hypsinotus* have prominent tubercles on the head extending from the nostrils nearly to the nape, as in *kentuckiensis*. The alleged difference in the size attained by these species largely fades away now that the present collection contains a specimen of *hypsinotus* 160 millimeters long, as well as others between 110 to 130 millimeters in length. The maximum size of this species previously was given as about 75 millimeters.

In color *hypsinotus* differs from *kentuckiensis* in having a more distinct dark lateral band and a more definite caudal spot. The differences in color, however, are not very evident in specimens over 75 to 80 millimeters in length, the larger individuals of both species being quite plain.

The following proportions and counts are based on 7 specimens ranging in length from 43 to 160 millimeters. Head 3.7 to 4.1; depth 3.9 to 4.63 in standard length. Eye 3.6 to 5.8; snout 2.35 to 3.2; maxillary 3.0 to 3.7; preorbital 3.9 to 4.8; pectoral 1.4 to 1.75; caudal peduncle 2.0 to 2.36 in head. D. II, 8; A. II, 7; scales 6—41 to 44—4 or 5; pharyngeal teeth 4–4.

16. NOTROPIS LUCIODUS (Cope)

Photogenis luciodus Cope. Proc. Acad. Nat. Sci. Phila., XIX, 1867, p. 165. Holston River, Virginia.

This species is represented by 52 specimens ranging in length from 32 to 70 millimeters. Ten of these specimens were taken in the Tuckaseegee River from Dillsboro to Bryson City, and the others are from the Ocono Lufty River near the Cherokee Indian School. The species is reported only from the upper Tennessee basin. The collections indicate that this minnow probably is not abundant in the Tuckaseegee River, but more numerous in its tributary, the Ocono Lufty River.

This species is recognized chiefly by the elongate, slender, scarcely compressed body, by the dark (purplish in life) lateral band which ends in a caudal spot. The caudal spot generally projects slightly on each

caudal lobe and often is shaped somewhat similar to an arrowhead. The species is described currently as having a "nearly straight" lateral line. In the specimens at hand, also in specimens from the type locality examined in the National Museum the lateral line is moderately decurved anteriorly. The fact that the curve is not as prominent as in some of the related forms may have led the describers to state that the lateral line is nearly straight. However, this statement seems somewhat misleading. Fowler (Proc. Acad. Nat. Sci. Phila., Vol. 62, 1910, p. 288, Pl. XX, fig. 45) who examined cotypes figures the species with a decurved lateral line.

The following proportions and counts are based on 10 specimens, ranging in length from 36 to 68 millimeters. Head 3.8 to 4.3; depth 5.35 to 5.6 in standard length. Eye 2.8 to 3.4; snout 3.5 to 4.0; maxillary 3.0 to 3.5; interorbital 3.1 to 3.5; pectoral 1.1 to 1.4; caudal peduncle 2.6 to 3.0 in head. D. I, 8 or 9; A. I, 8 to 10; scales 37 to 42, before dorsal 14 or 15; pharyngeal teeth 1, 4–4,1 (one specimen examined).

17. NOTROPIS COCCOGENIS (Cope)

Hypsilepis coccogenis Cope. Proc. Acad. Nat. Sci. Phila., XIX, 1867, p. 160, Pl. 27, fig. 5. Holston River, Virginia.

This species is represented by 36 specimens ranging in length from 32 to 93 millimeters, all taken in the Tuckaseegee River between Dillsboro and Bryson City. It is reported in the literature as common in the mountain streams forming the head-waters of the Tennessee River in North Carolina, and it is also recorded from the Cumberland and Savannah River basins. The relatively small number in the present collection indicates that this species is less common in Tuckaseegee River between Dillsboro and Bryson City than several related forms.

The specimens from the Tuckaseegee River were carefully compared with the type, with which they quite evidently are identical. This species is close to *N. brimleyi* from which it differs in the projecting lower jaw, *N. brimleyi* having the lower jaw a little shorter than the upper one (never projecting) and included within the upper jaw when the mouth is closed. No variation in the shape of the mouth, worthy of note, has been found. Therefore, the projecting lower jaw in the present minnow is regarded as a reliable specific character. In color, as well as in other respects, *N. coccogenis* and *N. brimleyi* appear to be alike. It apparently is worthy of note that the two species were not taken together in the same catches.

The following proportions and counts are based on 12 specimens

ranging in length from 32 to 93 millimeters. Head 3.9 to 4.25; depth 4.75 to 6.0 (young much more slender than the adults) in standard length. Eye 3.25 to 3.6; snout 3.1 to 3.8; maxillary 2.5 to 3.2; interorbital 2.9 to 3.4; pectoral 1.3 to 1.7; caudal peduncle 2.6 to 2.9 in head. D. I, 8 or 9; A. I, 9 or 10; scales 44 to 46, before dorsal 15 or 16; pharyngeal teeth 2, 4–4, 2 (one specimen examined).

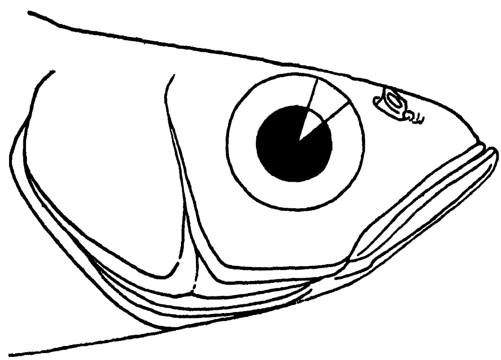


Fig. 1. *Notropis coccogenis.* Note strongly projecting lower jaw

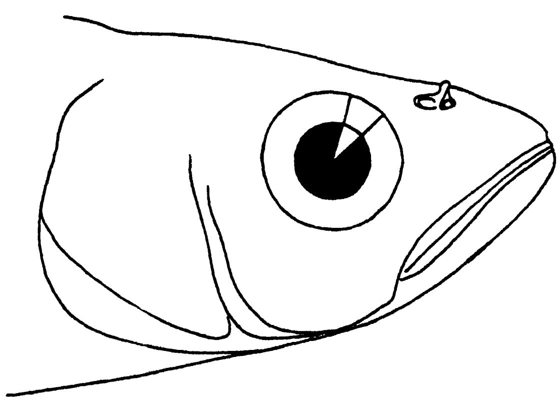


Fig. 2. *Notropis brimleyi.* Note scarcely projecting lower jaw

18. NOTROPIS BRIMLEYI B. A. Bean

Notropis brimleyi Bean. Proc. U. S. Nat. Mus., XXVI, 1903, p. 913. Cane River, North Carolina.

This species is represented by 99 specimens ranging in length from 35

to 92 millimeters. It was taken at several places in the Tuckaseegee River between Dillsboro and Bryson City and also in the Ocono Lufty River near the Cherokee Indian School. The species was recorded previously only from the Cane River, Yancey County, North Carolina. It seems to be fairly common in the localities where the present collections were made.

The specimens at hand were carefully compared with the type of *N. brimleyi* with which they undoubtedly are identical. The species is recognized principally by the moderately slender body (which is deeper, however, than in the related form, *N. arge*), by the large oblique mouth with the lower jaw included, and the maxillary reaching to or more usually a little beyond the anterior margin of the eye. Well preserved adults have a black bar extending from the shoulder downward to the base of the pectoral, and from one-third to one-half of the distal part of the dorsal and caudal fins is black. In small specimens under about 50 millimeters in length the dark shoulder band and the black on the fins is indistinct or wanting. This color apparently sometimes fades in larger specimens if not especially well preserved. In such cases the specimens sometimes are distinguished from *N. arge* with some difficulty.

The following proportions and counts are based on 9 specimens, ranging in length from 40 to 92 millimeters. Head 3.7 to 4.0; depth 5.0 to 5.4 in standard length. Eye 3.0 to 3.85; snout 3.2 to 3.4; maxillary 2.2 to 2.9; interorbital 3.0 to 3.5; pectoral 1.35 to 1.6; caudal peduncle 2.75 to 3.1 in head. D. I, 8 or 9; A. I, 9 to 11; scales 39 to 44, before dorsal 15; pharyngeal teeth 2,4–4,2 (one specimen examined).

19. NOTROPIS ATHERINOIDES Rafinesque

Shiner

Notropis atherinoides Rafinesque. Amer. Month. Mag., II, 1818, p. 204. Lake Erie.

Six specimens from the Tuckaseegee River, 3 each from Wilmot and Cullowhee, ranging in length from 90 to 115 millimeters are assigned to this species. The species is reported as very variable and of wide distribution, inhabiting the Great Lakes region and the Mississippi Valley, entering North Carolina through the Tennessee River.

The specimens at hand are a slender variety with rather more numerous scales in a lateral series, as well as in advance of the dorsal, than are assigned to the species. The lateral line is moderately decurved and

usually a pair of dark spots, one above and the other below each pore, is present on about the interior half of the body. The scales are not conspicuously black-edged, although a concentration of dark punctulations does take place on that part of each scale on the upper parts of the body.

The following proportions and counts are based on 4 specimens, ranging in length from 90 to 115 millimeters. Head 4.15 to 4.5; depth 5.2 to 5.9 in standard length. Eye 3.5 to 3.9; snout 3.4 to 3.55; maxillary 3.0 to 3.25; interorbital 3.0 to 3.6; pectoral 1.15 to 1.4; caudal peduncle 3.0 to 3.6 in head. D. I, 8 or 9; A. I, 9 or 10; scales 44 to 48, before dorsal 20 or 21; pharyngeal teeth 2,4–4,2 (2 specimens).

20. NOTROPIS SPECTRUNCULUS (Cope)

Shiner

Hybopsis spectrunculus Cope. Jour. Acad. Nat. Sci. Phila., VI, 1868 p. 231, Pl. 22, fig. 3. Holston River (Va?).

This species, known only from the headwaters of the Tennessee River is represented in the present collection by 55 specimens, ranging in length from 35 to 75 millimeters.

The fish were collected in the Tuckaseegee River, mostly between Dillsboro and Bryson City, and one lot of 6 specimens was taken in the Ocono Lufty River, near the Cherokee Indian School. It evidently is one of the common minnows in the Tuckaseegee River and its tributaries.

The species is characterized by the long slender body, rather broad depressed head (which is very nearly as wide as deep), and the rather large oblique and slightly inferior mouth with maxillary reaching anterior margin of eye. The specimens in the present collections have a triangular naked area reaching one-half to two-thirds the distance from the head to the dorsal fin, and occasionally a single row of scales is present on the vertebral line. This naked area is not mentioned in the original or in more recent descriptions, and it may not always be present Another distinguishing character is the black spot on the base of the caudal fin. This spot often has slight projections, extending slightly on the caudal lobes, making the spot shaped somewhat like an arrow head pointed forward.

The following proportions and counts are based on 9 specimens, ranging in length from 35 to 75 millimeters. Head 4.0 to 4.6; depth 5.5 to 7.25 in standard length. Eye 3.1 to 3.7; snout 3.1 to 4.0; maxillary

3.3 to 4.0; interorbital 3.2 to 3.8; pectoral 1.25 to 1.5; caudal peduncle 2.6 to 3.25 in head. D. I, 8; A. I, 8 to 10; scales 38 to 42, before dorsal 12 or 13; pharyngeal teeth 4–4 (2 specimens).

21. NOTROPIS GALACTURUS (Cope)

Milky-tailed minnow

Hypsilepis galacturus Cope. Proc. Acad. Nat. Sci. Phila., XIX, 1867, p. 160. Holston River, Va.

This large and well marked minnow is represented in the Tuckaseegee collection by over 200 specimens, ranging in length from 15 to 130 millimeters. It evidently is one of the most common species in the Tuckaseegee River. The species inhabits mountain streams from the Missouri to Virginia and North Carolina west of the Alleghany and Blue Ridge Mountains.

This fish is recognized by the rather slender body (which, however, shows considerable variation), inferior mouth, the black on the membranes between the last two or three dorsal rays, and especially by the pale yellowish spot at the base of each caudal lobe. These spots sometimes are joined by the same color, forming a pale yellowish band at the base of the caudal. The color markings at the base of the caudal are evident in specimens only about 20 millimeters in length. The black on the dorsal fin generally is not present, however, in specimens under about 60 millimeters in length. In the very young, under 25 millimeters in length, the mouth is nearly or quite terminal. Thereafter, as growth proceeds, it becomes inferior. Specimens about 70 millimeters in length have a dark lateral band on the caudal peduncle. In smaller ones it extends further forward, and in specimens about 35 millimeters and under in length, it reaches forward to the head. This band generally is entirely missing in adults. Large males have tubercles on the head. The specimens were compared with the type with which they appear to agree in detail.

The following proportions and counts are based on 9 specimens, ranging in length from 37 to 125 millimeters. Head 4.0 to 4.4; depth 4.1 to 5.3 (young notably more slender than the adults) in standard length. Eye 3.75 to 4.8; snout 3.0 to 4.0; maxillary 3.4 to 3.8; interorbital 2.4 to 3.0; pectoral 1.33 to 1.5; caudal peduncle 2.1 to 2.6 in head. D. I, 8 or 9; A. I, 9 or 10; scales 41 to 45, before D. 15 to 17; pharyngeal teeth 1,4–4,1 (two specimens examined). The type has D. I, 8; A. I, 9; scales 37, before dorsal 15.

22. NOTROPIS NIVEUS (Cope)

Hybopsis niveus Cope. Proc. Amer. Phil. Soc., XI, 1870, p. 460. Upper Catawba River, N. C.

This minnow is represented by 1 specimen from the Catawba at Old Fort, 8 specimens from Catawba Lake at Bridgeport, and by 15 specimens from creeks at Chapel Hill. These specimens range in length from 25 to 100 millimeters. While the species is reported as common in the upper Catawba by Cope, it evidently was not numerous in the vicinity of Old Fort in October, 1930, when the present collections were made. This minnow is reported from various streams east of the mountains from Virginia to South Carolina.

The species is recognized chiefly by the rather elongate body with a prominent dark lateral band, generally extending forward to the head but only to the shoulder in some of the larger specimens. The membranes between two or three of the posterior rays of the dorsal are largely black.

The mouth has been described as nearly terminal, without a projecting snout. This is true of small specimens, but not of the unusually large specimens taken at Chapel Hill, several of which are between 75 and 100 millimeters in length. (The generally recorded maximum size of this species is 2½ inches, or about 62 millimeters.) In the large individuals the snout projects distinctly beyond the mouth and becomes notably more pointed than in the young. The large males taken during the breeding season (May 24, 1930) are largely covered with tubercles and the rays of the dorsal fin are greatly produced, being about equal to the distance from the tip of the snout to the preopercular margin. The body becomes proportionately deeper and more strongly compressed with age and increase in size.

The following proportions and counts are based on 16 specimens, ranging from 25 to 100 millimeters in length. Head 3.75 to 4.25; depth 3.8 to 4.8 in standard length. Eye 4.25 to 5.8; snout 2.8 to 4.0; maxillary 3.55 to 4.2; interorbital 2.4 to 3.2; pectoral 1.2 to 1.55; caudal peduncle 2.1 to 2.5 in head. D. I, 8 or 9; A. I, 8 or 9; scales 36 to 42, before dorsal 14 or 15; pharyngeal teeth 0,4–4,0 (4 specimens examined, previously described as having also 1,4–4,1).

23. NOTROPIS PYRRHOMELAS (Cope)

Photogenis pyrrhomelas Cope. Proc. Amer. Phil. Soc., XI, 1870, p. 463. Upper Catawba River, N. C.

This minnow is represented by 29 specimens ranging in length from

25 to 86 millimeters taken in the Catawba River near Old Fort, and by 26 specimens ranging in length from 35 to 80 millimeters collected from creeks in the vicinity of Chapel Hill. This species has been recorded only from the Catawba and Yadkin basins. The range is now extended to the Cape Fear basin, as the creeks in the vicinity of Chapel Hill belong to that drainage system. This minnow apparently is common in the Catawba River at Old Fort and in the creeks in the vicinity of Chapel Hill.

This species is characterized largely by the rather deep body, oblique terminal mouth (projecting slightly in large specimens) with the maxillary reaching nearly or quite opposite the anterior margin of the small eye. The short, broadly forked caudal fin, the dark shoulder band, the dark margin on the caudal fin and the black on the posterior interradial membranes of the dorsal fin, also, are helpful in recognizing the species.

The following proportions and counts are based on 22 specimens, ranging in length from 25 to 86 millimeters. Head 3.6 to 4.25; depth 3.45 to 4.2 in standard length. Eye 3.6 to 5.25; snout 2.9 to 4.0; maxillary 3.0 to 4.0; interorbital 2.45 to 2.85; pectoral 1.3 to 1.5; caudal peduncle 2.1 to 2.8 in head. D. I, 8 or 9; A. I, 9 to 11; scales 35 to 39, before dorsal 13 or 14; pharyngeal teeth 0,4–4,0 (4 specimens examined).

24. NOTROPIS RUBRICROCEUS (Cope)

Hybopsis rubricroceus Cope. Jour. Acad. Nat. Sci. Phila., VI, 1866–69 (1869), p. 231. Tumbling Creek, tributary North Fork Holston River, Va.

This minnow, known from the upper waters of the Tennessee and Savannah Rivers, is represented by 69 specimens, ranging in length from 20 to 60 millimeters, all collected near old Fort from the Catawba River and its tributaries. It apparently is one of the most abundant species of the vicinity.

This species is described as having the pharyngeal teeth in two rows with 4 teeth in the outer row and 2 teeth in the inner one. In 6 specimens examined the second or inner row consisted constantly of 1 small slender tooth, placed extremely close to the teeth of the outer row. It is probable that there is variation in the number of teeth in the second row, as all other characters seem to agree well with Cope's original description and colored plate. Cope states that 19 rows of scales are present anterior to the dorsal fin. In the specimens at hand this is the greatest number found. The range in 28 specimens counted is 15 to 19, the usual number being 17 or 18, with 19 rows occurring in only 1 specimen.

This species is characterized by: (a) the posterior position of the dorsal fin, its origin being fully an eye's diameter behind the insertion of the ventrals, and nearer the base of the caudal than tip of snout; (b) the rather small scales and numerous rows crossing the back in advance of the dorsal; and (c) color, the lower parts of the body being largely red in life, sides with a dusky lateral band, and without black on the dorsal fin.

The following proportions and counts are based on 8 specimens (unless otherwise indicated), ranging in length from 25 to 57 millimeters. Head 3.75 to 4.0; depth 4.2 to 4.6 (5.0 in very young) in standard length. Eye 3.0 to 3.6; snout 3.4 to 4.0; maxillary 3.0 to 3.7; interorbital 2.75 to 3.5; pectoral 1.05 to 1.4; caudal peduncle 2.3 to 2.9 in head. D. I, 9; A. I, 9 or 10; scales 38 to 42, before dorsal 15 to 18 (27 specimens); pharyngeal teeth 1,4–4,1 (6 specimens).

25. NOTROPIS HUDSONIUS (De Witt Clinton)

Shiner; Spawn-eater; Spot-tailed minnow

Clupea hudsonius De Witt Clinton. Ann. Lyc. Nat. Hist. N. Y., I, 1824, p. 49. Hudson River.

This species, ranging from New York to Georgia and to the Dakotas, is represented by 10 specimens from the Catawba River near Old Fort, varying in length from 27 to 50 millimeters, and 28 specimens taken in creeks in the vicinity of Chapel Hill which range from 52 to 95 millimeters in length. These specimens evidently represent the variety *saludanus* Jordan and Brayton (Bull. U. S. Nat. Mus., XII, 1878, p. 16), originally described from a tributary of the Saluda River, Greenville, S. C.

The North Carolina fish were compared with specimens from Chatauqua Lake, N. Y. The New York specimens are believed to be typical *hudsonius*. The snout in the North Carolina fish appears to be slightly longer, as well as broader, and it extends just a little farther beyond the mouth. The difference in the length of the snout is most evident when specimens of the same size are compared. In North Carolina fish about 85 to 95 millimeters long the snout is very nearly as long as the greatest diameter of the eye, whereas it is evidently shorter than the diameter of the eye in the New York specimens of the same size. Furthermore, the North Carolina fish appear to have slightly larger scales anteriorly, as only 12 or 13 and occasionally 14 rows cross the back in advance of the dorsal, whereas the New York

specimens have from 14 to 16 rows before the dorsal. A dark lateral band is present in all the specimens examined. However, in the New York fish the band is more or less expanded to form a larger and more pronounced caudal spot than in the Carolina specimens.

The following proportions and counts are based on 11 specimens, 7 from Old Fort and 5 from Chapel Hill, ranging in length from 25 to 95 millimeters. Head 3.75 to 4.6; depth 4.3 to 5.0 in standard length. Eye 3.1 to 4.0; snout 3.1 to 4.2; maxillary 3.2 to 4.05; interorbital 2.5 to 3.6; pectoral 1.2 to 1.6; caudal peduncle 2.2 to 3.0 in head. D. I, 8 or 9; A. I, 8 or 9; scales 5–35 to 40–4, before dorsal 12 or 13 (rarely 14); pharyngeal teeth 0,4–4,0 (3 specimens) 2,4–4,2 (1 specimen).

26. NOTROPIS sp.

Three specimens, respectively about 40, 50, and 52 millimeters in length, were taken in the Catawba River near Old Fort which I have not been able to identify with any known species. Owing to their rather poor condition, the fins and scales being lost in large part, an accurate description can not be given, and their exact relationship can not be determined at this time. In general, the specimens are rather near *N. scepticus.* However, a comparison of these specimens with the type of that species shows that the Catawba fish are notably more slender (depth 4.0 in length in the type) the scales are more numerous (34 in a lateral series in the type) and the anal fin is longer (I, 9 in the type of *N. scepticus*). The color in *N. scepticus* is largely silvery on the sides, whereas the specimens from the Catawba River, having been preserved in formalin, do not show silvery color, but do have a narrow dark lateral band, most distinct on posterior half of body.

The following proportions and counts are based on the three specimens at hand. Head 3.75, 4.0, and 4.0; depth 4.55, 4.9, and 5.05 in standard length. Eye 3.2, 3.3, and 3.4; snout 3.5, 3.5, and 3.5; maxillary 3.0, 3.2, and 3.25; interorbital 3.2, 3.4, and 3.6; caudal peduncle 2.55, 2.6, and 2.75 in head. D. I, 8 or 9; A. I, 12 or 13; scales 37 or 38.

Family CENTRARCHIDAE

27. MICROPTERUS DOLOMIEU Lacépède

Small-mouth black bass

Micropterus dolomieu Lacépède. Hist. Nat. Poiss., IV, 1802, p. 325. Type locality uncertain, probably South Carolina.

This important food and game fish with a natural range (which has

been greatly extended through artificial means) extending from Vermont westward through the Great Lakes region to Manitoba and southward to Arkansas and South Carolina, was found to be common in the Tuckaseegee River wherever collections were made. Only young were taken, probably because nearly all the collecting was done with "minnow seines." The species was not taken in the Catawba River. The collection contains 58 specimens, ranging in length from 40 to 140 millimeters, taken at the following places on the Tuckaseegee River: Ela, Dillsboro, Wilmot, Weavers Island, Cullowhee, and Bryson City. It was taken also in the Ocono Lufty River near the Cherokee Indian School. Its congener, the large-mouth bass, was not taken.

The following proportions and counts are based on 6 specimens, ranging in length from 45 to 90 millimeters. Head, 2.75 to 2.9; depth, 3.45 to 3.9 in standard length. Eye, 3.1 to 4.5; snout, 3.0 to 3.8; maxillary, 2.25 to 2.8 in head. D. X or XI, 13 or 14; A. III, 11; P. 16 to 18; scales 75 to 80.

28. AMBLOPLITES RUPESTRIS (Rafinesque)

Rock bass; Red-eye

Bodianus rupestris Rafinesque. Amer. Month. Mag., II, 1817, p. 120. Lakes of New York, Vermont and Canada.

The rock bass ranges from Vermont through the Great Lakes region to Manitoba and southward in the Mississippi Valley probably as far as Louisiana. In North Carolina it is believed to occur naturally only west of the Alleghanies. The species is represented in the present collection by 8 specimens, ranging in length from 30 to 175 millimeters. These fish were taken in the Tuckaseegee River at Dillsboro and Bryson City, and in the Ocono Lufty River near the Cherokee Indian School.

The following proportions and counts are based on 3 specimens respectively, 44, 76, and 175 millimeters in length. Head, 2.55 to 2.95; depth, 2.25 to 2.75 in standard length. Eye, 2.9 to 3.85; snout, 3.85 to 4.2; maxillary 2.3 to 2.8; interorbital 3.2 to 4.2; pectoral 1.55 to 1.75; caudal peduncle, 2.4 to 2.6 in head.

29. LEPOMIS AURITUS (Linnaeus)

Long-eared sunfish; Red-bellied Bream; Robin perch

Labrus auritus Linnaeus. Syst. Nat., Ed. X, 1758, p. 283. Philadelphia, Pa.

The collection contains 29 small specimens, ranging from 22 to 45

millimeters in length, all taken in the Catawba River near Old Fort, which are somewhat doubtfully referred to this species. It is well known, of course, that young sunfishes are difficult to identify. However, in the specimens at hand the number of dorsal and anal rays, the number of scales, in a lateral series, the short and few gill-rakers, the small mouth (the maxillary reaching anterior margin of eye), and the short and well rounded pectoral fin all suggest *L. auritus*. The specimens are too small to give any indication of the shape that the opercular flap is destined to assume. Neither is the adult color pattern developed. The larger specimens are plain in spirits, with a black spot on the opercle. The smaller ones are lighter and generally bear indications of cross-bars.

The long-eared sunfish is rather widely distributed, being known from the Atlantic and Gulf drainages from Maine to Louisiana. It was reported as common in the Catawba River by Cope in 1870.

The following proportions and counts are based on 6 specimens, ranging in length from 32 to 45 millimeters. Head, 2.5 to 2.9; depth, 2.4 to 2.8 in standard length. Eye, 3.0 to 3.3; snout, 3.6 to 4.2; maxillary, 2.9 to 3.3; pectoral, 1.4 to 1.9 in head. D. X or XI, 10 or 11; A. III, 8 to 10; scales, 42 to 47; gill-rakers, 7 or 8.

Family ETHEOSTOMIDAE

30. HYPOHOMUS AURANTIACUS (Cope)

Orange-colored darter

Cottogaster aurantiacus Cope. Jour. Acad. Nat. Sci. Phila., VI, Pt. III, 1869, p. 211. Holston River, Saltville, Virginia.

This species is represented by one large specimen 145 mm. long, taken in the Tuckaseegee River near Dillsboro, N. C. This darter apparently is limited in its distribution to the upper tributaries of the Tennessee River, being known from only about 10 specimens taken in Holston, Watauga, Clinch, French Broad, and Tuckaseegee Rivers.

This darter is rather showy, and it grows larger than most species of darter. The proportions in the specimen in hand differ somewhat from those given in current descriptions, probably because of its large size. Head, 4.5; depth, 4.7; pectoral, 4.9 in standard length. Eye, 4.65; snout, 3.1; maxillary, 3.25; caudal peduncle, 4.9 in head. D. XIV–14; A. II, 10; scales 14–110–14.

In alcohol the general color of the upper parts is dark brown and the lower parts are straw color. A dark lateral band, composed of rather obscure dark connected blotches, is present. The fins are mostly grayish

and have no definite markings. Doctor Gutsell describes the color of this specimen when fresh in his field notes as follows: "Underside of head brilliant red; venter, except breast, brilliant orange; breast gray; upper parts greenish; sides with darker spots or bars; dorsal fins olive green, the first dorsal margined with deep orange, the second one margined with a lighter orange; anal and ventrals slate gray; pectorals washed with gray and green."

The small scales, which are extended on the cheeks, opercles, nape and on the median line of the abdomen, are very helpful in recognizing the species. The posterior margin of the caudal fin is very slightly concave and the lobes are rounded.

31. HADROPTERUS EVIDES (Jordan & Copeland)

Barred darter

Alvordius evides Jordan and Copeland. Proc. Acad. Nat. Sci. Phila., XXIX, 1877, p. 51. White River near Indianapolis, Indiana.

This darter, an inhabitant of the Mississippi basin, apparently is one of the more common ones in the Tuckaseegee River and its tributaries. Eight specimens were taken in the Tuckaseegee, in the general vicinity of Dillsboro, and one was taken in the Ocono Lufty River near the Cherokee Indian School.

The specimens probably are typical. The cheeks and chest are naked, and the opercles and nape are covered with scales. One specimen has a row of large modified scales on the median line of the belly, in the others this part of the abdomen is naked. Vomerine teeth are present. In some specimens the dark lateral spots on the sides form more or less definite cross bars, while in one specimen the dark lateral spots are roundish to oval and well separated from the quadrate blotches on the back.

The following proportions and counts are based on 7 specimens, ranging in length from 48 to 64 mm. Head, 4.0 to 4.15; depth, 5.3 to 6.1; pectoral, 3.4 to 4.0 in standard length. Eye, 3.75 to 4.3; snout, 3.43 to 3.95; maxillary, 2.7 to 3.25; caudal peduncle, 2.6 to 2.9 in head. D. XII or XIII–11 to 13; A. II, 8 or 9; scales, 60 to 66.

32. PŒCILICHTHYS ZONALIS Cope

Blue-banded darter

Pœcilichthys zonalis Cope. Jour. Acad. Nat. Sci. Phila., VI, Pt. III, 1869, p. 212, Pl. 24, fig. 1. Holston River, Va.

Two specimens of this darter, 51 and 54 mm. long, were taken in the Ocono Lufty River near the Cherokee Indian School. The species inhabits the Mississippi basin to northern Indiana.

Evidently some variation with respect to the squamation of the cheeks and opercles occurs. Cope's figure of the type shows the cheeks and opercles fully covered with scales. A slight indication of a few small scales on the upper part of the opercles is present in the Ocono Lufty River specimens, while the cheeks are entirely naked. In 10 specimens from Cumberland Gap, Tenn., examined for this character, all have evident scales on the opercles and most of them have slight indications of a few scales on the cheeks. Cope's figure shows the chest scaled, also. It is entirely naked in the two specimens in the present collection, as well as in 10 specimens from Cumberland Gap, Tenn.

Cope's figure shows 7 dark blotches on the back, whereas only 6 are mentioned in his description. The specimens in hand have 6 blotches which are placed somewhat differently from those shown in Cope's figure, their position being as follows: First one is just in advance of the first dorsal, the second one almost under the middle of the base of first dorsal (Cope's figure shows 2 blotches under the base of the first dorsal), the third occupies the space between the dorsal fins, the fourth is a little in advance of the middle of the base of second dorsal, the fifth is just behind base of the second dorsal, and the sixth one is on the caudal peduncle, a little in advance of the base of the upper rays of the caudal fin. Cross bars are evident only below the lateral line in the specimens at hand, whereas they are indicated as extending nearly to the back in Cope's figure. Furthermore, the bars are wider and less definitely defined than indicated in Cope's figure. No definite lateral stripe is present in the specimens at hand.

The following proportions and counts are based on the 2 specimens taken in the Ocono Lufty River: Head 4.4 to 4.47; depth 5.2 to 5.5; pectoral 3.5 in standard length. Eye 3.2 to 3.3; snout 3.3 to 3.5; maxillary 3.3 to 5.2; caudal peduncle 2.1 in head. D. X or XI–13; A. II, 7 or 8; scales 46 and 48.

33. PŒCILICHTHYS CAMURUS Cope

Blue-breasted darter

Pœcilichthys camurus Cope. Proc: Amer. Phil. Soc., XI, 1870, p. 265. Headwaters Cumberland River in Tenn.

The blue-breasted darter, ranging from Lake Erie to Tennessee, is represented by three specimens, two (43 and 52 mm. long) from the

Ocono Lufty River near the Cherokee Indian School and one (80 mm. long) from the Tuckaseegee River near Dillsboro.

The small specimens from the Ocono Lufty River are darker in color than the large one from the Tuckaseegee, and have irregularly placed dark spots on the sides, whereas the large specimen has no spots. One specimen from the Ocono Lufty has the dorsal and caudal fins spotted and barred with black dots, while these fins, except for dark margins and a lighter intramarginal band, are plain dusky in the other two specimens. The large specimen has a large rectangular pale spot (yellow in life) in front of the dorsal, which is missing in the small specimens. This pale area is not mentioned in current descriptions. It apparently is present only in large specimens and probably only in females. Specimens from Tippecanoe River, Indiana, were examined for this character. The largest one, 73 mm. long, also showed evidence of a similar pale area. Although the color appears to vary, all specimens examined agree in having more or less definite dark longitudinal streaks between the rows of scales.

The largest specimen (80 mm. long) at hand is proportionately deeper and the snout is notably less pointed than in the smaller ones. The following proportions and counts are based on the 3 specimens in the present collection: Head 3.6 to 4.0; depth 4.0 to 4.8; pectoral 3.8 to 4.4 in standard length. Eye 3.35 to 3.8; snout 3.4 to 4.0; maxillary 3.0 to 3.35; caudal peduncle 1.7 to 2.1 in head. D. XII or XIII–12 or 13; A. II, 7 or 8; scales 53 to 60.

34. POECILICHTHYS THALASSINUS (Jordan and Brayton)

Sea-green darter

Nothonotus thalassinus Jordan and Brayton. Bull. U. S. Nat. Mus., No. 12, 1878, p. 13. Reedy River, Greenville, S. C.

Three specimens, respectively 29, 33, and 65 mm. in length, taken in the Catawba River near Old Fort, are referred to this species, which is known only from the Santee basin of North and South Carolina.

The specimens from Old Fort differ from the type, with which they were compared, in the absence of scales on the nape. However, slight outlines of scales are discernible in this region in two of the specimens at hand. In the type the nape is fully covered with well developed scales. A good comparison of the color can not be made, as the type is badly faded. The markings are identical as far as discernible. Some of the characteristic markings of the species consist of a black spot on

the membrane between the first two dorsal spines, and short dark cross bars on the lower part of the sides. In two of the specimens at hand the bars are connected at their upper extremity by a dark lateral band. The third specimen is very dark dorsally and on upper parts of the side, and a lateral band is not evident.

The following proportions and counts are based on the three specimens from the Catawba River: Head 3.85 to 4.05; depth 5.1 to 5.4; pectoral 3.3 to 3.53 in standard length. Eye 3.0 to 3.95; snout 3.4 to 3.75; maxillary 3.45 to 3.6; caudal peduncle 2.15 to 2.4 in head. D. X–11 or 12; A. II, 8; scales 41 to 43.

Pœcilichthys thalassinus is rather closely related to *P. swannanoa* (of which the type specimens were examined) of the Tennessee River basin. However, according to the specimens compared *P. thalassinus* has a deeply concave to almost forked caudal fin, while the margin of this fin is round in *P. swannanoa.* Furthermore, *P. thalassinus* has somewhat larger scales, 41 to 43 oblique rows above the lateral line, whereas the two type specimens of *P. swannanoa* have respectively 54 and 56 oblique rows.

35. PŒCILICHTHYS FLABELLARIS BREVISPINIS (Coker)

Fan-tailed darter

Etheostoma flabellaris Rafinesque. Journal de Physique, 1819, p. 419. Tributaries of Ohio River.

Richia brevispina Coker. Bull. Bur. Fish., XLII, 1926, p. 106, fig. 1. Paddys Creek, Burke Co., N. C.

This darter is represented in the present collection by 14 specimens, ranging in length from 26 to 56 mm., all taken in the Catawba River and its tributaries near Old Fort.

The specimens were carefully compared with the type and two paratypes of *Richia* (later replaced by *Richiella, Richia* being preoccupied, Coker, Copeia, No. 162, 1927, p. 17) *brevispina* with which they certainly are identical. Myers (Copeia, No. 163, 1927, p. 39) and Hubbs (Copeia, No. 163, 1927, p. 43) have pointed out that Doctor Coker's new genus probably was not well founded, and these writers expressed the opinion that Doctor Coker's nominal species, at most, represents only an eastern race of the fan-tailed darter. *P. flabellaris.* Hubbs suggests, furthermore, that Girard's name *Oligocephalus humeralis* would be available for an eastern species or subspecies of fan-tailed darter.

The present writer has carefully compared the Paddys Creek and Catawba River specimens with specimens of fan-tailed darter from Johns River, N. C., James River, Va. (a large lot of "type specimens" of *Oligocephalus humeralis* Girard), West Virginia (no definite locality), Tazewell, Tenn., and Mill Creek (probably Putnam Co.) Ind. Careful proportional measurements and scale and finray counts were made. It is evident from this study that the Paddys Creek and Catawba River specimens differ somewhat in several characters, most of which appear to intergrade with other material. However, the differences are such that the writer feels justified in regarding Doctor Coker's name, *brevispinis*, as of at least subspecific rank until such a time when a more thorough study, for which the necessary material and time are now not available, is made. Girard's name *humeralis* is not available for the Paddys Creek and Catawba River specimens, because the type of specimens of *humeralis* differ in the squamation of the abdomen and nape, the former having ordinary scales and the latter being naked or partly scaled, and somewhat in the number of dorsal and anal rays.

The Paddys Creek and Catawba River specimens differ from others examined as follows:

a. In having, at most, only a few scales on the median line of the abdomen, this region much more usually being naked. In 14 specimens only 1 has a few scattered scales behind the vent. In the other specimens examined of this group of darters, the abdomen is largely and occasionally fully covered with scales, no specimen having been seen in which the median line of the abdomen is wholly naked.

b. The nape is always naked in *brevispinis*. In other specimens of fan-tailed darters, the nape frequently is wholly or partly covered with scales.

c. The average number of dorsal spines and rays is lower in *brevispinis*. In 14 specimens from the Catawba River and 3 from Paddys Creek, 7 specimens have 6 spines, and 9 specimens have 7, none having 8. In 39 specimens from other localities 2 have 6, 18 have 7, and 19 have 8. Somewhat similarly in 14 specimens from the Catawba River and 3 from Paddys Creek the second dorsal has 12 rays in 12 specimens, 13 rays in 5, and none with 14 rays, while in 32 specimens from other localities the second dorsal has 12 rays in 8 individuals, 13 in 19 specimens, and 14 in 5 specimens.

d. The average number of soft rays in the anal fin also is lower. In

17 specimens from the Catawba River and Paddys Creek, 9 specimens have 7 rays, 7 have 8 rays, and none with 9 rays, whereas in 19 specimens from other localities 7 have 7 rays, 11 have 8, and 1 has 9 rays.

e. The lateral line extends nearly or quite opposite end of base of second dorsal in *brevispinis*. While there is much variation in specimens from other localities, the lateral line generally extends only under the base of the first dorsal.

No differences in color, which appear to be of specific or subspecific importance, have been noticed. The different color phases which have been mentioned in the literature apparently are largely correlated with six. The rather plain specimens with definite dark cross bars are males and large ones have the tips of the dorsal spines much expanded or shovel-shaped. Large females do not have definite cross bars, and no enlargements at tips of fin rays.

The following proportions and counts are based on 9 specimens from Old Fort: Head 3.2 to 4.0; depth 4.8 to 6.6; pectoral 3.5 to 4.75 in standard length. Eye 3.5 to 4.45; snout 3.75 to 4.75; maxillary 3.1 to 3.2; caudal peduncle 1.85 to 2.23 in head. D. VI or VII–12 or 13; A. II, sometimes I or III, 7 or 8; scales, 42 to 52.

36. PŒCILICHTHYS GUTSELLI sp. nov.

Gutsell's darter

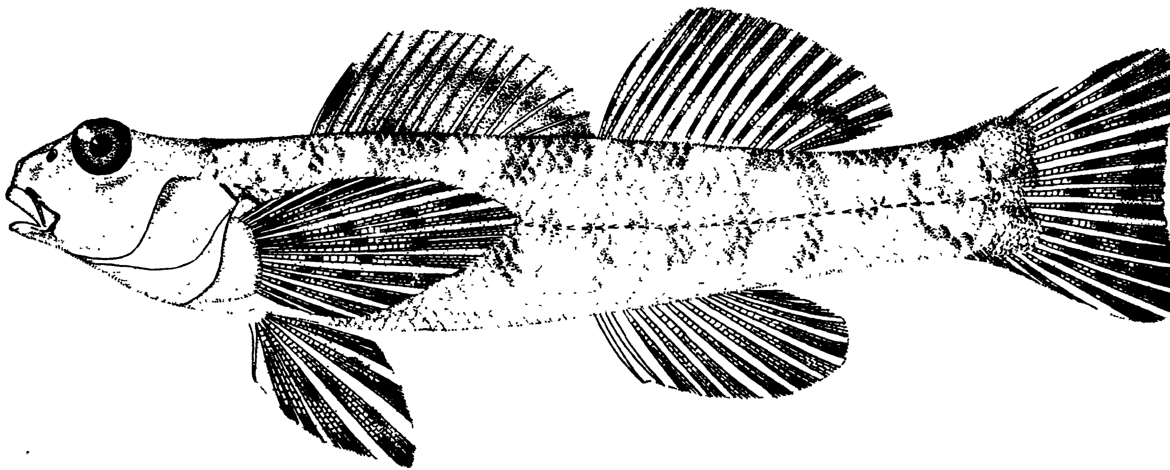
Type U. S. N. M. No. 92402; length, 84 mm. Tuckaseegee River, Ela, North Carolina.

Three specimens of darter from the Tuckaseegee River, two taken at Ela and one at Cullowhee, apparently are not referable to any known species. The necessity of proposing a new name, therefore, arises. The writer takes pleasure in naming the species for the collector not only of this darter, but of the collection on which this paper is based, Dr. James S. Gutsell, associate aquatic biologist with the Bureau of Fisheries.

Description of the type.—Head 4.44; depth 6.15; D. XIII–14; A. II, 8; scales 7–53–8.

Body quite elongate, nearly as broad as deep in advance of dorsal fins, compressed posteriorly; caudal peduncle rather deep, its depth 2.2 in head. Head low, broad ventrally, as broad as deep at margins of preopercles; snout blunt, longer than eye, 2.8 in head; eyes placed high, rather close together, 3.5 in head; mouth small and low, nearly hori-

PLATE 3



Pœcilichthys gutselli sp. nov. From the type, 84 mm. long.

zontal; lower jaw included; maxillary reaching below anterior nostril, 4.85 in head; premaxillaries not protractile, attached to forehead by a moderately broad median frenum; teeth pointed, in bands on jaws, similar teeth on vomer; gill membranes very broadly united across the isthmus; lateral line nearly straight and complete; scales rather small, ctenoid, missing on head, chest, median part of nape, and on a triangular area behind ventrals; dorsal fins contiguous, the first one longer but lower than the second one, origin of the first dorsal equidistant from tip of snout and origin of second dorsal; origin of second dorsal equidistant from upper anterior angle of opercle and base of caudal; posterior margin of caudal fin slightly concave, the angles rounded; anal fin much smaller than second dorsal, its origin slightly behind that of second dorsal, the 2 spines of about equal length, the first the stronger; longest soft rays about equal the longest ones of the second dorsal; ventral fins of moderate size, failing to reach origin of anal by about twice the diameter of the eye; pectorals rather large, reaching slightly past the tips of ventrals, somewhat longer than head, 3.93 in standard length.

Color in alcohol mostly pale brown, the upper parts with many dark markings. The median naked portion of the nape mostly dark brown; back with 6 broad quadrate blotches, the first under the fifth to the ninth spines of the first dorsal, the second under the last spines of this fin, the third under the anterior part of second dorsal, the fourth under the posterior rays of second dorsal, the fifth just behind the base of second dorsal and the sixth almost at base of upper lobe of caudal. In addition to many indefinite markings on the upper part of sides, 7 rather definite dark bars are situated on lower part of sides principally below lateral line. A rather definite dark stripe extends from eye to muzzle; other more or less irregular dark markings are present on sides of head; and a dark scale is evident above and behind base of pectoral. The dorsals, caudal and pectorals are profusely spotted and barred with dark markings, the bars being most distinct on the caudal. An elongate black spot is present on the membrane between the first two dorsal spines. The anal fin is plain translucent and the ventrals have only a few faint dusky blotches.

Two paratypes, one 87 mm. long taken with the type, and the other 45 mm. long from the Tuckaseegee River near Cullowhee are at hand. The following proportions and counts are based on the paratypes, the first figure given in each instance is based on the larger specimen and the second on the smaller one: Head 4.3 and 4.35; depth 5.4 and 6.2; pectoral 3.4 and 3.7 in standard length. Eye 3.4 and 3.05; snout 2.7

and 2.8; maxillary 3.8 and 3.85; caudal peduncle 2.1 and 2.2 in head. D. XIII–14 and XIII–15; A. II, 8 and II, 9; scales 53 and 54.

The variations in the type and the large paratype are exceedingly small. The small specimen varies somewhat more evidently. However, the variations may be due principally to age. The snout in the small specimen appears to be blunter; the opercles are rather more vertical, yet the width of the head at the margin of the preopercles is very nearly as great as its depth; and the caudal margin is somewhat more deeply concave. The bars on the lower part of the sides are more distinct, and the naked region of the nape is dark posteriorly only.

The generic relationship of this darter with respect to the rather depressed cranium and the well separated ventral fins (the space between them being equal to width of the base of the fin) are with Hypohomus, but the small anal fin connects it with Pœcilichthys. The broadly united gill membranes and well separated ventrals ally it with the subgenus Nanostoma.

The species is characterized principally by the rather low broad head; anteriorly rounded body; the blunt snout; small inferior mouth; the entirely naked head, chest, nape, and anterior part of the abdomen (the posterior part of the abdomen being covered with ordinary scales); and the long dorsal fins.

37. BOLEOSOMA EFFULGENS (Girard)

Effulgent darter

Arlina effulgens Girard. Proc. Acad. Nat. Sci. Phila., XI, 1859, p. 64. Tributaries of Potomac River, D. C.

Boleosoma maculaticeps Cope. Proc. Amer. Phil. Soc., XI, 1870, p. 269. Upper Catawba River, N. C.

This darter, known from Maryland to North Carolina, is represented by 7 specimens, ranging in length from 35 to 43 mm., taken in the Catawba River near Old Fort. In addition, Dr. R. E. Coker supplied 9 specimens, 41 to 61 mm. in length, from Bowlins Creek (Cape Fear River drainage) near Chapel Hill, N. C.

The specimens from the two localities named were carefully compared and found to be identical. They were in turn compared with the type of *Arlina effulgens* Girard with which they appear to agree in structure and also in color in so far as a comparison can be made, the color in the type having faded. The relationship between this form and *B. nigrum*, and its subspecies has not been worked out well and remains for future study.

The cheeks, chest and nape are naked in all the specimens in the present collection. The opercles generally have a few scales, but occasionally are almost wholly covered. In one specimen, only, one opercle is entirely naked while the opposite opercle has two embedded scales. No scales are evident on the head, chest or nape in the type of *B. effulgens.*

A breeding male (61 mm. long) from Chapel Hill, taken April 26, 1930, has prominent fleshy knobs on the ends of the outer ventral rays, also on the lower pectoral rays, and slight enlargements on the tips of the first 4 dorsal spines. A smaller male (53 mm. long) has similar, but smaller, enlargements on the tips of these fin rays. A large female (54 mm. long), heavy with roe, taken at the same time and place has no indications of enlarged fin ray tips. Knobs on the tips of certain fin rays, therefore, appear to be developed only in males. Since they are present only in ripe or nearly ripe males in the specimens examined, it seems probable that the enlargements may be present only during the breeding season and that they disappear afterwards, similar to the tubercles often developed on the heads of various species of minnows (Cyprinidæ) during the breeding season.

The males in general are darker in color than the females. However, all the North Carolina specimens have the characteristic dark markings on and below the lateral line, forming rather definite W-shaped marks.

The nominal species *B. maculaticeps* Cope was described from the upper Catawba. Cope's description is quite incomplete and no figure is given. All the characters described seem to suit the specimens at hand. It seems quite probable, therefore, that *B. maculaticeps* properly belongs in the synonymy of the present species.

The following proportions and counts are based on the specimens from Old Fort: Head, 3.7 to 4.0; depth, 5.8 to 4.0; pectoral, 3.33 to 3.55 in standard length. Eye, 3.0 to 3.65; snout, 3.0 to 4.0; maxillary, 2.8 to 3.4; caudal peduncle, 2.5 to 2.83 in head. D. VIII or IX-12 or 13; A. I, 7 to 9. (While the anal generally is described as having a single spine, certainly the second and often the third rays are undivided and are "spines" just as truly as the first one, which is not pungent and is wholly covered with soft tissue.) Scales, 42 to 45.

Proportions and counts based on the specimens from Chapel Hill are as follows: Head, 3.4 to 4.4; depth, 5.75 to 6.3; pectoral, 3.4 to 3.9 in standard length. Eye, 3.2 to 3.6; snout, 2.9 to 3.2; maxillary, 2.8 to 3.6; caudal peduncle, 2.2 to 2.8 in head. D. VIII or IX–12 to 15; scales, 42 to 48.

The following measurements and counts, based on the type *Arlina effulgens* Girard, a specimen 78 mm. long, were made by the present writer: Head, 3.9; depth, 5.8; pectoral, 4.65 in standard length. Eye, 3.3; snout, 3.25; maxillary, 2.8; caudal peduncle, 2.4 in head. D. VIII–14; A. I, 9; scales, 44.

Family COTTIDAE

38. COTTUS ICTALOPS (Rafinesque)

Miller's thumb

Pegedictis ictalops Rafinesque. *Ichth. Ohiensis, 1820, p. 85.* Kentucky.

Two specimens of this species were taken in the Tuckaseegee River, one at the mouth of Dicks Creek and the other near Bryson City. This widely distributed fish, ranging from New York to the Dakotas and southward to Kansas and Alabama, has been reported previously in North Carolina only from the tributaries of the French Broad River.

The following proportions and counts are based on the two specimens at hand. Head, 3.15 and 3.35; depth, 4.2 and 4.65 in standard length. Eye 2.7 and 3.7; snout 2.6 and 3.05; maxillary 2.4 and 2.5; interorbital, 6.0 and 9.8; pectoral .75 and 1.0; caudal peduncle 3.0 and 3.4 in head. D. VII–16 and VIII–17; A. 12 and 13.

ABSORPTION OF WATER BY THE LEAVES OF COMMON MESOPHYTES

By Harold F. Williams

Plates 4 and 5

Introduction

The purpose of this paper is to emphasize the probability that the leaves of a considerable number of ordinary land plants are capable under certain conditions of absorbing water, and to point out some of the implications which this involves. While it must be stated emphatically at the outset that the conditions under which leaf absorption is possible by common mesophytes probably seldom occur in nature, yet, considered as a plant phenomenon in experimental plant science, this would seem worthy of wider recognition. The attention given to the subject in textbooks indicates, where the possibility is recognized at all, that modern workers do not generally regard leaf absorption as of any significance in the water economy of ordinary land plants. The conditions under which water may be absorbed by the leaves of a number of mesophytic species appear to be: first, when they possess a surface which can be wetted; second, when they are surrounded, in part at least, by liquid water; and third, when there is a sufficient internal deficit of water. Leaves of some plants are no doubt incapable of absorbing water under any conditions.

Historical Discussion

Dandeno (1901) and Wetzel (1924) have given very complete historical discussions and extensive bibliographies on the subject of water absorption by leaves. Haberlandt (1914) gives valuable references to the earlier literature and discusses in detail special features of water absorption by aerial organs. Kerner and Oliver (1895) give a rather extended general discussion. If one considered all phases of the absorption of water and substances in solution in water by all types of leaves and other aerial organs, a very extensive bibliography could be prepared. It is intended herein to give only a brief, critical review of pertinent literature. The present bibliography does not contain all the

papers pertaining to the subject of water absorption by the leaves of mesophytes, but it will lead the reader to most of the literature.

Mariotte, writing in 1679 (1717, p. 133. Sachs, 1890, p. 461), describes two experiments which he performed to demonstrate leaf absorption. In the first, a small branch of a tree or herb bearing a lateral branchlet was cut off and immersed in water so that the branchlet with its leaves was exposed to the air. In some cases the branchlet remained fresh for several days; in others, for as long as two weeks. In the second, he immersed the older leaves of chives and noted that they, together with the exposed leaves, remained fresh for two weeks and that the younger leaves elongated several inches. He concluded that rain, dew, and water vapour are adsorbed by leaves and branches. Stephen Hales (1769) describes an experiment similar to Mariotte's. His illustration is probably the first one to be published on this subject. Hales concluded that leaves vary in their capacity to absorb water and that rain and dew are absorbed, especially in dry seasons.

During the period between the time of Hales (1769) and that of Henslow (1880), doubts have been expressed as to the ability of leaves to absorb water and as to the value of leaf absorption to ordinary land plants, these two points not always being clearly separated. Henslow believed that he had settled the matter of rain and dew absorption in the affirmative. By his numerous ingenious experiments in which he used whole plants, cut shoots, or detached leaves of plants belonging to over fifty genera, he proved that most leaves certainly possess the ability to absorb water. The fact that these leaves absorbed water under the given conditions is not, however, proof that rain and dew are absorbed under natural conditions. Boussingault (1878), a contemporary of Henslow, concludes that absorptive ability is widespread and that rain and dew are absorbed.

The conclusions of Duchartre (1857, 1861) were that leaves are incapable of absorbing water to any appreciable extent, and that the "function" of moistening a leaf surface by rain or dew is to diminish transpiration. The general acceptance of these conclusions was perhaps the chief reason why absorption of rain and dew, and leaf absorption in general, came to be doubted. Duchartre maintained that cut shoots and detached leaves are not normal and hence can not be used to prove that water is absorbed in nature. His conclusion that leaves are incapable of absorbing rain and dew rests, as Henslow points out, upon unsound experimental method. He disregarded the matter of supply and demand, i.e., that a certain extent of absorbing leaf surface can supply a

certain area of transpiring leaf surface, depending on the kind of leaf and the rapidity of transpiration. If this balance is short on the side of absorbing surface and long on that of the transpiring surface, especially if the whole plant has been allowed to wilt previous to the application of water, then one may erroneously conclude that wetted leaves do not absorb water. Henslow understood this principle and expressed it as follows: " . . . . The general conclusion being that the duration of life in the specimen thus treated depends upon the supply being equal to the demand. The absorbing-power is incontrovertible; but the amount of foliage exposed varies the demand upon the power of imbibition" (p. 318).

The experiments described by Ganong (1894) in which he used whole potted plants show considerable lack of appreciation of the above principle. An example of this lack may be given: "Exp. b. Strong plant of *Senecio petasites*; herbaceous, broad-leaved, 2 feet high, branching just above base into two nearly equal stalks. Of one stalk about half its length was wrapped with filter paper kept constantly wet. In open air of room. . . . . Tenth day, all leaves dry and withered and stem drooping; a disinterested person could not tell which was most wilted" (p. 140).

In this experiment the unwrapped stem was the control. Clearly one should not expect the surface of one half of the stem of such a plant to absorb sufficient water to supply that required in transpiration by the leaves of the entire plant. In this experiment it would have been instructive to compare the extent of the surface of the stem covered with filter paper with the normal absorbing surface of roots and root hairs. In experiments of this kind one is concerned not only with supplying the transpiration needs of the aërial parts, but also with maintaining the turgidity of the entire subaërial portions of the plant.

It has been pointed out by Smith, Dustman, and Shull (1931) that if a root saturation deficit exists it may be relieved by a supply of free water from any direction. To test the absorption of water applied in drops, they sprayed certain wilted plants for several minutes. No increase in weight occurred. It would have been more judicial, perhaps, to have sprayed the plants continuously, or at least for longer periods, and to have compared them with unsprayed controls. In another experiment, they allowed young *Helianthus* plants 14 and 18 inches high to droop over until they touched the table, after which certain of the leaves were submerged but there was no apparent recovery. One wonders if they would have revived if water had been supplied to the roots.

The writer believes that cut shoots must in some way differ from potted plants, since in repeating some of Henslow's experiments similar results were obtained. It is difficult to conceive that a cut shoot of a plant is so very abnormal, and next to impossible to understand how such an operation on a plant, would affect the permeability of leaves to water. Henslow in an experiment in which he used a whole potted plant, apparently demonstrated the ability of leaves to absorb water. With reference to this experiment, Ganong points out that after a month many roots had been produced from submerged nodes. Burt (1893) describes several experiments in which rooted plants absorbed water applied as spray to their leaves. He determined by weighing that absorption took place. Since not all weights are given, it is rather difficult to judge whether the gains in weight are certainly significant.

Dandeno (1901) demonstrated the water absorbing ability of the leaves of about thirty genera of land plants not investigated by Henslow. This was determined mostly by increase in weight and by appearance of detached leaves and cut shoots. He points out that weighing may not accurately determine increase due to water absorption, since leaves often lose substances, generally alkaline in nature, to the surrounding water. Spalding (1906) shows that the leaves of certain species of desert plants, which retain well marked mesophytic tendencies, are capable of absorbing water. Delf (1911, 1912), although not primarily concerned with ordinary mesophytes, gives data which indicate that the few used were capable of absorbing water. He shows that, even though apparently fresh and turgid shoots were used, sometimes there was a gain in weight after immersion. This seems to show that there may be a range in the normal water content which would allow absorption, provided water is present on the aërial organs. Halket (1911) showed that certain halophytes possess the ability to absorb water from a salt solution and that certain mesophytes do not. They, however, were able to absorb pure water.

Wetzel (1924) demonstrated, by using detached leaves and weighing them after submergence in water, that approximately 100 species of plants are able to absorb water, and that the cuticle did not completely prevent absorption, except when it is covered with a waxy bloom or a dense mat of hairs. He concluded that the power of absorption is widespread among mesophytic leaves, but that it is of no particular advantage in the water economy of ordinary plants of temperate climates. Zimmerman and Hitchcock (1928) studied the absorption by leaves of cuttings, but their results have apparently not yet been published in detail.

The subject of water absorption by leaves of mesophytes has received some attention in the more recent textbooks of plant physiology and botany. In a few texts, mention of the possibility is entirely omitted and in none is the utilization of leaf absorption in experimental plant science stressed. In earlier texts of plant physiology (Vines, 1886; Detmer and Moor, 1898; Pfeffer, 1900) absorption in many plants under certain conditions is regarded as a possible but not a usual function of leaves. The same general conclusions are arrived at in more recent works (Maximov, 1929 and 1930; Miller, 1931). The subject is receiving attention in several very recent general texts (Eyster, 1932; Torrey, 1932).

The absorption of water by leaves of plants other than ordinary mesophytes, notably epiphytes, certain desert plants, and plants living submerged should also be mentioned. Kerner and Oliver (1895) and Haberlandt (1914) have rather extended discussions of water absorption by leaves and of special adaptations for this function. Volkens (Maximov, 1929) has pointed out that certain desert plants obtain almost their entire supply of moisture from dew. Epiphytes, particularly among the Bromeliaceae, which possess special absorbing scales, have been extensively studied. Gates (1914) demonstrated that certain evergreen ericads absorb water vapour.

The question of the absorption of substances in solution by mesophytic leaves has been but slightly investigated. If water can be absorbed by certain leaves, it would appear probable that solutions of some substances may be absorbed also. Early investigators, for example Boussingault (1878), noted that if a dilute solution of calcium sulphate is placed on a leaf and not allowed to evaporate too rapidly, the salt is completely absorbed finally. If drying was rapid, however, a deposit was formed on the leaves. Dandeno (1901) grew certain plants with their roots in distilled water and supplied a nutrient solution to the leaves as a spray. Since a substantial growth occurred and since the actual content of ash in proportion to dry weight increased, there appears to be no doubt that the leaves absorbed some of the substance applied in the form of a spray. He also demonstrated that certain salts could be absorbed through both leaf surfaces of either attached or detached leaves if the surrounding atmosphere was favorable. Absorption by way of the lower surface was usually the greater. Dr. F. A. Wolf, in unpublished work on tobacco frenching, reported at the 1932 meeting of the North Carolina Academy of Science that if the stem tip with affected leaves is immersed in a solution of manganese salts, these

leaves become normal. Immersion in certain other salts or in water does not bring about this change.

In summary, published conclusions show that the power of water absorption by the stems and leaves of ordinary land plants is widespread, also that these parts are incapable of absorbing appreciable quantities of water. Again, it has been concluded that such absorption is important in the life of ordinary plants under certain conditions, and conversely that such absorption is of no significance. In publications where one would expect comment, no mention of the subject is made, nor is any stress placed on the possibility of utilizing an absorbing system of aërial organs in experimental work.

EXPERIMENTS

The following statement by Lubimenko (1927, p. 383) was submitted at a seminar in answer to the query, "Do leaves absorb water?" "En tout cas il est certain que les organes aériens de nos plantes terrestres sont capable d'absorber l'eau et ce fait es établi déjà par l'expérience classique de Hales." This conclusion is modified by the preceding sentence in which he states that in the great majority of cases the root system plays an exclusive rôle in water absorption, water absorption by aerial organs being generally insignificant. This statement is worthy of note in that it distinguishes the capability of aerial organs to absorb water from the actual absorption in nature. Hales (1769, p. 133) describes his experiment as follows: "Experiment XLII. July 27th, I repeated Mons. Perault's experiment; *viz.* I took *duke-cherry*, *apple* and *currant-boughs*, with two branches each, one of which *a c* ([his] Fig. 25) I immersed in the large vessel of water *e d*, the other branch hanging in the open air: I hung on a rail, at the same time, other branches of the same sorts, which were then cut off. After three days, those on the rails were very much withered and dead, but the branches *b* were very green; in eight days the branch *b* of the *duke-cherry* was much withered: but the *currants* and *apple-branch b* did not fade till the eleventh day: whence it is plain, by the quantities that must be perspired in eleven days, to keep the leaves *b* green so long, and by the waste of the water out of the vessel, that these boughs *b* must have drawn much water from and through the other boughs and leaves *c*, which were immersed in the vessel of water."[1]

It seemed desirable to repeat this experiment, but in such a fashion

[1] A similar illustration is given by Boussingault (1878, p. 366) and by Pfeffer (1900, p. 160).

that the leaves alone would be the absorbing structures. If a plant is cut off and inverted in a vessel of water, and some of the older leaves of the stem left exposed to the air, one approximates Hales' experiments. It should be borne in mind in experiments of this type that a cut shoot is used, that the plant part is inverted, and that the younger leaves are the absorbing ones. If the exposed leaves remain turgid for a considerable period, one could conclude that water entered by way of the submerged leaves. To be strictly impartial, this could be due to use of a cut shoot or to inversion. The arguments tending to show that a cut shoot is legitimate material for such an experiment have already been reviewed. As to the condition of inversion, it is well known that in nature water moves equally readily in either direction in a normal plant. Experiments similar to Hales' experiments were performed with *Nicotiana tabacum, Arachis hypogaea,* and *Lycopersicum esculentum* grown in the greenhouse. Under a slightly different set of conditions, parts of single leaves of *Fraxinus americana* and *Verbascum Thapsus* were submerged and the behavior of the exposed parts observed. Also entire plants of *Allium canadense, Eleusine indica,* and *Brassica rapa,* except for a portion of the root system, were inverted in water in such a manner that some of the leaves were submerged and others exposed.

Experiments with Nicotiana tabacum: Four two-months-old tobacco plants of the Cash variety were used in one experiment. They were selected for similarity in size, appearance, and number of leaves. Two were cut off near the ground level, inverted in jars of tap water in the manner shown in Figure 2, and held in place by a cotton plug. The level of the water was adjusted so that only those leaves and parts of leaves extending beyond the apical bud were wetted. Two healthy leaves remained exposed to the air above the edge of the jar. Two other plants were similarly fastened in jars so that two leaves were exposed with only enough water in the jar to keep the air saturated. They were then placed in the greenhouse.

These experiments were set up at 2:30 p.m., Jan. 6. By 4 o'clock the exposed leaves of the plants without submerged leaves, designated *C* and *D*, were wilted; the exposed leaves of the other two plants, *A* and *B*, were turgid. At the end of the day plants *B* and *D* were placed in a southwest window, while *A* and *C* were left in the greenhouse. During the next two weeks the exposed leaves of *A* and *B* remained turgid except when illuminated with direct sunlight, and then became turgid again about sunset and remained so for the night. The area of the absorbing surface was roughly 1.5 to 2 times greater than that of the

transpiring surface. The control plants remained permanently wilted and soon dried.

At the end of three weeks (Jan. 27) water was added to both jars, enough in *A* to fill it to the cotton plug and enough in *B* to cover again the parts which had become exposed by the loss due to evaporation. The behavior of these plants during the three weeks showed that they were still "living" things, as shown by the following observations. At the end of a week (Jan. 13), the leaf nearest the plug had changed from a horizontal to a vertical position. A twisting was apparent in the petiole. Upon wilting, however, the blade resumed its horizontal position. By the end of two weeks the lower leaf of each plant had completely turned over, so that the morphologically upper surface was now in fact uppermost. After this period, if the leaves wilted, the blades remained with their surfaces in the reverse position.

Both plants A and B made an abortive attempt to produce roots from the region near the cut end of the stem. This was manifest by the slight cracking of the surface of the stem and by the slightly exerted tips of the roots. On Jan. 25, plant A was observed to be producing roots from the portion of the stem between the cotton plug and the water. Some roots had reached a length of a half inch. No tendency to produce roots was at this time observable on plant *B*.

At the end of three weeks a bud in the axil of the lower exposed leaf of *A* had started development. During this time also the submerged leaves of both plants had retained a considerable amount of chlorophyll. The plants had increased in size, apparently *A* more than *B*, although no measurements were made. The stem tip of *A* certainly increased in length about one inch and bent upward against the cotton stopper. The exposed leaves retained their green color scarcely unchanged.

At the end of 22 days the water in Jar *A* was replaced with soil solution to favor root development, and the upper part of the jar covered with paper. Figure 1 is of plant *A*, on Jan. 31, in soil solution. Roots from the submerged portion of the stem, a developing axillary bud, the curve in the apical stem region, and the inversion of the lower exposed leaf may be observed. Figure 2 is of plant *B*, on Jan. 31, whose leaves only were in contact with water. It had been in direct sunlight and the exposed leaves are wilted. The lower exposed leaf has completely turned over. Figure 3 is of plants *A*, *B*, and one of the controls on the morning of Feb. 2. The turgidity of two of the exposed leaves of *B* is noteworthy, whereas the upper one, which was nearly dead at the time when the plant was cut off level with the soil, is dead.

Plant *A* was transferred to soil Feb. 2. It has produced about 75 roots, the longest being 1.5 inches, in four or five irregular longitudinal patches. The stem tip was apparently dead. The few roots which had grown into the cotton plug were broken off in handling. Most of the submerged leaves fell away as the plant was pulled from the water. The remaining leaves which had been submerged were removed. Figure 4, *A* is a photograph of this plant on Feb. 23. Three axillary buds are developing. The lowermost one gradually outstripped the other two, which finally died (fig. 5, *A*). For 21 days the only parts of this plant in contact with the water were certain of its leaves. Plant *B* underwent a somewhat similar history. No water was allowed to come in contact with its stem until the end of four weeks when soil solution was added. On Feb. 21, it was transferred to soil, by which time it had produced about thirty roots, the longest being about three inches. Figure 4, *B* is of plant *B*, on Feb. 23. The lowest of the exposed axillary buds continued development (Fig. 5, *B*) although later a still lower one pushed up through the soil. These two buds continued developing for over three months. For 28 days the only parts of this plant in contact with water were certain of its leaves. During this time water had been moving through sections of the stems in a direction the reverse of normal. Secondary thickening had apparently gone on normally in these sections of the stems.

Experiment with Arachis hypogaea: An experiment similar to that performed with tobacco, using two-months-old peanut plants, gave similar results. On Feb. 22, at 3:00 p.m. three plants were cut off a few inches above the soil and inverted in jars as in the preceding experiment (Fig. 6). In Plant *A*, those leaves which extended beyond the apical bud were submerged in water, leaving two exposed to the air. Two leaves of plant *B* were exposed and the remainder enclosed in the saturated atmosphere of a jar partly filled with water. Plant *C* was similarly arranged in an empty jar. The jars were placed in the greenhouse in bright sunlight. At 7 p.m. the exposed leaves of plant *A* were widely expanded. Those of *B* and *C* were partly closed and were quite flaccid. By this time the lower of the two exposed leaves of all plants was attempting to turn over. Figure 6 is of these three plants the next morning at 11 a.m. The exposed leaflets of plant *A* are turgid and widely expanded. The blade of the lower leaf has turned through an angle of 90 degrees. Although the exposed leaves of *B* and *C* are wilted, they have begun to turn over.

Figure 7 is of the same plants 14 days later at 10 a.m. The reoriented

leaflets of plant *A* are still turgid and the exposed leaves of *B* and *C* are dry and brown. One leaflet of plant *B*, which was accidentally in partial contact with the inside of the jar, remained green and fresh. The portion of this leaflet in contact with the jar apparently was able to absorb enough water which had condensed on the wall of the jar to supply the entire leaflet. This parallels dew-formation and its absorption in nature. This leaflet and a portion of another one also in contact with the jar are shown in Figure 7, *B*. No leaflet, not in contact with the jar, showed any trace of chlorophyll at this date. Figure 8 is of the same plants at 10 p.m. on the same date, 14 days after setting up. The exposed leaflets of plant *A*, especially those of the lower leaf, are closed, as is normal with peanut leaves at night. At least with respect to this nyctotropic movement, *A* may be said to be living.

During the first week of the experiment the submerged leaves of *A* opened and closed nearly normally, after which the tendency to close was less evident. At the end of a week, eosin solution was added to a jar containing a plant which had been set up at the same time and in the same way as *A*, and which had behaved in the same manner. No trace of eosin appeared in the exposed leaves, indicating that water was not entering through the leaf surface. In the experiment with tobacco, eosin readily appeared in the exposed leaves if an incision was made in the absorbing leaves. The terminal bud of plant *A* bent upward during the course of the experiment. No evidence of root production was observed. At the end of a month the exposed leaves of *A* were still green, although somewhat paler than normal. The exposed leaves of *B* were dry and light brown in color as were all the leaves of *C*. None of the enclosed leaves of *B* except the leaflet in contact with the jar, showed any chlorophyll. It may be concluded that the leaves of *Arachis hypogaea*, at least those near the apex, are capable of absorbing water.

Miscellaneous experiments: Three other species of plants were used in experiments begun about 8 p.m. April 14, and photographed 24 hours later after they had been in the green house in bright sunlight all day. Figure 9 shows an experiment with wild onion, *Allium canadense*, similar to that described by Mariotte in 1679 with chives. About half of the leaves of each plant in flask *A* were immersed in water, the other half being exposed to the air. No water was placed in flask *B* containing an equal number of similar plants. The exposed leaves of plants *A* remained turgid for several days. It is improbable that they remained so because of lack of transpiration.

A portion of the leaves of young plants of goose grass, *Eleusine indica*,

were partly submerged in *A* and the leaves in *B* received no water. They were photographed 24 hours later, as shown in figure 10. The exposed leaves of *A* are normally turgid. This plant later produced several aerial roots which finally reached the bottom of the test tube.

Figure 11 is of two inverted shoots of tomato 24 hours after the experiment was started. Water had been added to *A*, none to *B*. A small portion of the stem, together with the apical leaves of plant *A*, was necessarily submerged. This plant first manifested a tendency to produce roots near the cut end of the stem and later formed many near the level of the water.

A number of other experiments may be mentioned. A single compound leaf of *Fraxinus americana* was fastened in a flask by means of a cotton stopper in such a manner that the five terminal leaflets were submerged in water, and the two axial ones were exposed to the air. Another leaf was similarly placed in a flask containing a saturated atmosphere. The exposed leaflets in the first flask remained fresh and turgid for more than a week, while those in the second wilted and dried within two days.

A single large leaf of *Verbascum thapsus* was rolled up and placed in a flask containing tap water so that about half was covered, the petiole half being exposed to the air. A similar leaf was likewise placed in a flask containing no water. The latter completely wilted within two days. The former remained turgid, supporting itself in the flask, as originally placed, for more than two weeks. Due to the felt of hairs on a mullein leaf, a drop of water placed thereon rounds up and does not wet the surface. A drop of water falling from the height of a few feet, however, readily wets the surface. In the above experiment, both leaves were thoroughly wetted by a stream of tap water before they were placed in the flasks.

Finally, an experiment may be mentioned in which rather badly wilted turnips were used. When they were placed in flasks in such a manner that most of the leaves were submerged, and a few exposed to the air, those exposed became turgid. To test whether water was entering through abrasions, the water was replaced with an eosin solution. No eosin appeared in the tap root of the turnip. When, however, several leaves were cut and the cut ends reimmersed, the eosin rose in the vascular tissue and colored a ring of tissue near the periphery. Boussingault, using beet (1878, p. 368), figures a similar experiment.

GENERAL DISCUSSION

In all cases in which certain of the leaves were submerged, the exposed leaves of such plants remained turgid longer than exposed leaves of similar plants, part of whose leaves were enclosed in a saturated atmosphere. Hence, it can not be argued that the former remained turgid because transpiration was greatly retarded by such submersion. Neither is the argument sound that cut shoots are abnormal with regard to leaf absorption, since cases have been described in which certain of the leaves of entire plants have absorbed water and-or substances in solution which supplied other leaves on the same plant. The experiments herein described with *Allium canadense*, *Eleusine indica*, and *Brassica rapa* are of this type.

The behavior of the inverted plants over a period of weeks as shown by root production, reversal of leaf surface, and increase in size indicates that they remained living. Moreover, certain meristematic regions remained capable of forming new tissues. Reversal of a plant such as tobacco may have some occult influence tending to make the submerged leaves permeable to water. Turgidity of the exposed leaves is best explained on the basis of their continued transpiration resulting in an increased saturation deficit in the cells of the submerged leaves, which are in consequence enabled to absorb water. This would not be likely to occur in nature because the saturation deficit of leaf cells would probably not be sufficient. Even if it were, a leaf with such cells would not likely become surrounded with liquid water. If, however, the epidermis is entirely incapable of being wetted, due to a waxy bloom or heavy felt of hairs, no water could be absorbed.

As a general rule, any leaf surface or herbaceous stem that can be wetted may absorb water, the ability varying with the leaves of different species, as Hales first pointed out. If leaf absorption is widespread among ordinary plants, then the nature of the discussion and the amount of space devoted to it seem to the writer peculiarly inadequate. Some of the main factors in this situation appear to be the following. First, absorption of water and of substances in solution in water (other than gases) is not a normal function of mesophytic leaves. Second, there is often a confusion of the two questions, do leaves customarily absorb water? and are they under any circumstances capable of such absorption? Third, evidence advanced for leaf absorption has not always been strikingly positive. Fourth, upon tenuous evidence some writers have assumed that leaves absorb rain and dew in considerable amounts. Fifth, evidence based on the use of cut shoots or detached

leaves to demonstrate leaf absorption is not acceptable to all. Sixth, some widely known experiments entirely disregard the ratio of absorbing to transpiring surface. Seventh, emphasis is placed on the cuticle as a structure to minimize transpiration. Eighth, it is difficult to devise a technique whereby aerial organs can be surrounded with liquid water in a satisfactory manner. Ninth, different leaves of the same plant or leaves of different plants vary in their capacity to absorb water. Tenth, it appears impossible for some leaves to absorb water under any circumstances. And eleventh, there are no clear cut and outstanding experiments which utilize leaf absorption in either practical or theoretical plant science.

It seems probable that water does not enter through the stomates into the intercellular spaces, but through the cuticle, as established by Wetzel and Dandeno. If water can be lost through the cuticle, it is not illogical to expect that it can enter also. In cases where stomates are numerous on both surfaces of the leaf, water might enter by way of the guard cells. By using leaves of plants which possess no stomates on the upper surface, Dandeno demonstrated that water may enter through the cuticle. He accurately measured the amount of water lost by the lower surface when only the upper was in contact with the water. Henslow and others have made similar observations. Since Copeland (1900) has shown that carbon dioxid diffuses more rapidly when the cuticle is kept moist, he concluded that water may pass through the cuticle. Awano (1909) investigated leaves of 264 plants and found that 164 were wetted with difficulty or not at all, while the remainder were readily wetted. Detmer (1898) and others have observed that in some cases the silvery luster of submerged leaves, indicative of a cuticle not readily wetted, gradually disappears upon extended submergence.

Although leaf absorption of water probably plays no significant part in the natural life of ordinary land plants, it would seem that the capability of leaf absorption by such plants is worthy of utilization in experimental and theoretical plant science. Since "the whole question of the permeability of plant cells in general is in a very unsatisfactory position. . . ." (Barton-Wright, 1930, p. 64) a more detailed study of water and dissolved substances should aid in the solution of the problem. In some cases it should be possible to measure the extent of the absorbing surface with considerable accuracy.

The behavior of the inverted plants described in this paper is interesting although it does not necessarily prove anything either for or against a theory of water movement in plants. The reversal of the water cur-

rent, which apparently occurs almost instantaneously in tobacco and peanut, is at least worthy of note.

Utilization of leaf absorption in experiments on nutrition and stimulation of plants may be suggested. If water can enter leaves, substances in solution probably can enter also. This entrance of substances may, as in the case of manganese into tobacco leaves, be sufficient in amount to cause morphological or functional changes without causing damage to the photosynthetic organ by too prolonged submergence. The problem of the entrance through leaves of the essential elements and of others, taken in conjunction with the entrance through roots, is at least worthy of investigation. It is not easy to demonstrate the value of supplying part of the minerals through the leaves and the remainder through the roots because of the difficulty of separating the effects produced. Leaf absorption of substances is, however, one of the matters to be considered when substances are applied to leaves as fungicides or insecticides.

In a study of the anatomy and ecology of *Arachis hypogaea*, Reed (1924, pp. 296–297) makes the following observations: "The roots are scantily provided with root hairs; in fact, it is very difficult to show that hairs of any kind are formed. . . . . When we know that the leaf has characters typical of mesophytic plants with only a few xerophytic characters, it is difficult to explain how the plant grows so well and fruits so abundantly in the driest portion of our southern summers." It is not meant to imply that the root supply of water in peanuts is augmented by leaf absorption, although this is a possibility.

The behavior of inverted plants is sufficiently remarkable to merit further investigation in regard to inversion of exposed leaves, apical dominance, and internal correlations, particularly as to root production and potentialities of cells.

". . . . The whole-range of cellular potentialities may not be exhibited in a plant living under what we call 'normal' conditions. To comprehend the extent of this range it is necessary to observe the plant under all conditions, ... that it is capable of enduring" (Allen, 1923, p. 396).

In the experiments with tobacco and tomato, root production was first manifest only in the region near the cut end of the stem. A cut shoot of tomato similar to that of Fig. 11, A, produced 369 root primordia within three weeks. McCallum (1905, pp. 117 and 255) noted the same phenomenon in connection with an inverted plant of *Phaseolus*.

If the capacity for absorption is a widespread characteristic of leaves

this likewise is one of the potentialities upon which natural selection may act. The possibility of tiding a valuable plant over a critical period by leaf absorption may be suggested. In this connection, Henslow points out that if cuttings are difficult to root burying some of the attached leaves may aid. He also comments on the preservation of cut flowers by utilizing leaf absorption, but it is necessary to know the behavior of each species in this respect, since petal fall may be hastened.

The selective absorption of toxins to kill weeds is discussed by Dandeno, but here as in similar cultural practices it is difficult to distinguish between leaf and root absorption of such substances.

It is desirable to know the proportion of absorbing surface required to supply a given extent of transpiring surface in different kinds of plants. The question of absorption by entire plants needs evaluation and further investigation. A study of absorption of nutritive and-or stimulating substances by leaves should prove valuable. The behavior of inverted plants in the light and in the dark might be investigated with respect to reorientation of leaves and root production. The influence of age and location of leaves on absorption of water, and its underlying anatomical and physiological causes might be critically examined.

Summary

1. A brief, critical review of the literature on leaf absorption by mesophytes is attempted. The leaves of plants in well over 100 genera have been described by different investigators as being capable of absorbing water.

2. Experiments are described using cut shoots of *Nicotiana tabacum*, *Arachis hypogaea*, and *Lycopersicon esculentum*, whole plants of *Allium canadense*, *Eleusine indica*, and *Brassica rapa*, and detached leaves of *Fraxinus americana* and *Verbascum thapsus* in which absorption of the water by the leaves was demonstrated. In these cases water absorption by the submerged leaves or parts of leaves was sufficient to supply other leaves or parts of leaves exposed to the air for considerable periods of time.

3. An attempt is made to analyze the bases for the largely erroneous belief that leaves are incapable of absorbing water.

4. Absorption of water by leaves of many mesophytic plants is of little significance in the normal life of these plants due to the absence of appropriate conditions for absorption.

5. An attempt is made to point out the need for investigations of some of the relations between the ability of mesophytic plants to absorb

water and substances in solution and experimental and theoretical plant science.

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EXPLANATIONS OF PLATES

PLATE 4

(See text for details)

Fig. 1. Plant *A*, Jan. 31. Jar filled with soil solution.

Fig. 2. Plant *B*, Jan. 31. Leaves only submerged in water.

Fig. 3. Plants *A*, *B*, and *C*, Feb. 2. Note exposed leaves of *B* in contrast with Fig. 2.

Fig. 4. Plants *A* and *B* after being transferred to soil, Feb. 23. *A* transferred Feb. 2, *B*, Feb. 21.

Fig. 5. Plants *A* and *B*, March 15.

PLATE 5

Fig. 6. Two months old peanut plants set up Feb. 22 at 3 p.m. Photographed Feb. 23 at 11 a.m. Certain leaves submerged in *A*; saturated atmosphere in *B*; no water added to *C*.

Fig. 7. Same plants as Fig. 6, photographed Mar. 7, 14 days later, at 10 a.m. Note turgidity of exposed leaves of *A* and one leaflet of *B* inside the jar in contact by half of its surface with the glass.

Fig. 8. Same, Mar. 7 at 10 p.m. Note closed exposed leaflets of *A*.

Fig. 9. *Allium canadense*. Set up at 8 p.m., April 14, photographed 24 hours later. Plants *A* have certain of their leaves submerged in water. No leaves of plants *B* were in contact with liquid water.

Fig. 10. Young plants of *Eleusine indica*. Set up at 8 p.m., April 14, photographed 24 hours later. Plant *A* has certain of its leaves submerged in water contained in a large test tube supported in a pot filled with sand. *B* similarly supported but no water added to the test tube.

Fig. 11. *Lycopersicum esculentum*. Cut shoots inverted at 9 p.m., April 14, photographed 24 hours later. Plant *A* has certain of its leaves and a short portion of the stem submerged in water. No water added to *B* flask.

PLATE 4

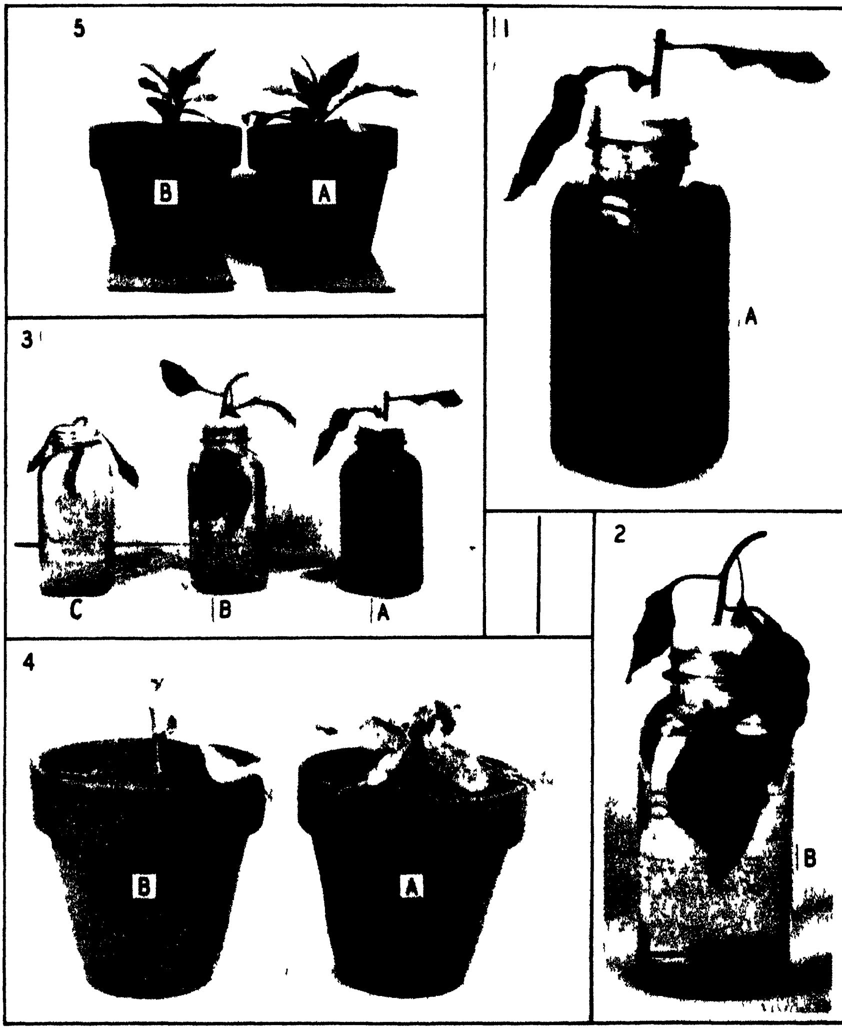
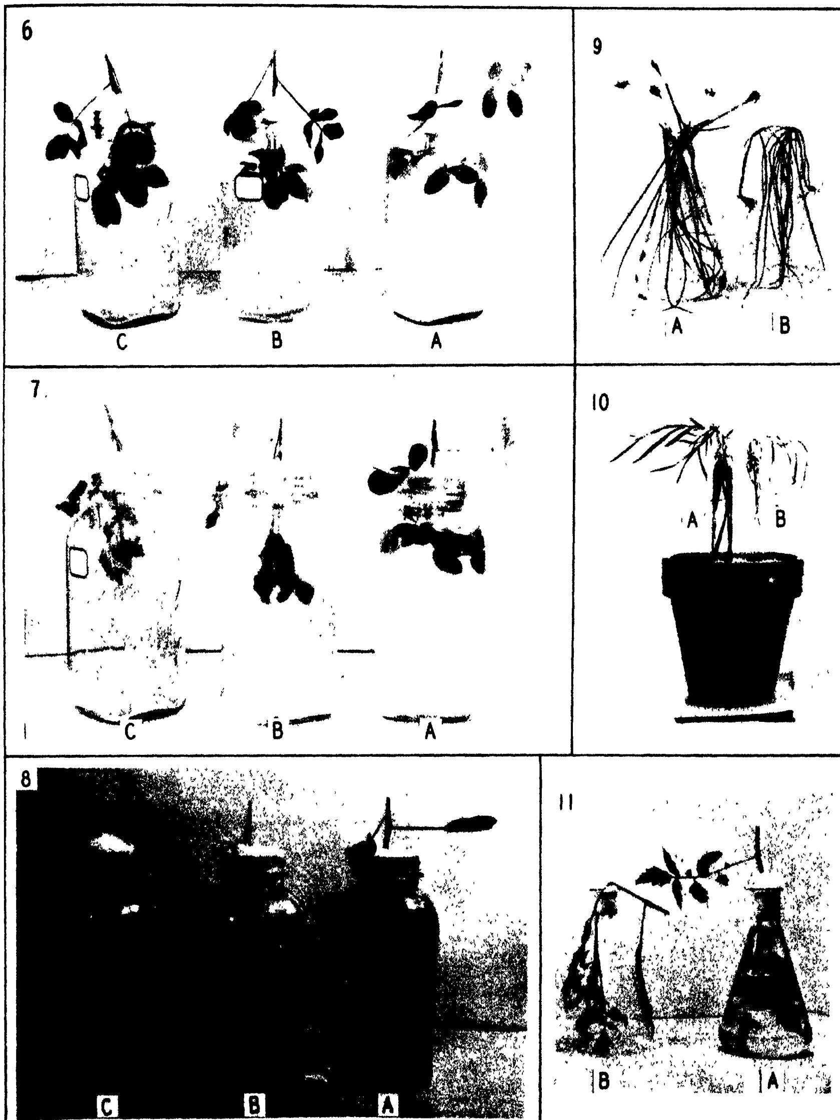


PLATE 5



THE SEED DEVELOPMENT IN PINUS PALUSTRIS

By A. C. Mathews

Plates 6–12

Introductory and Historical Notes

Although a large amount of work has been done on the development of the seed in species of *Pinus*, nothing of this nature has been recorded for any one of the southern pines. The following is a treatment of the development of the seed in *Pinus palustris* (long leaf pine), a well known pine greatly admired for its beauty, and of great commercial importance in the south.

Ferguson (1904) gives a very thorough account of the details from sporogenesis to early proembryogeny in *Pinus* and a summary of the literature relative to these details in the Abietineae. Her study was chiefly of *Pinus strobus*, but she says: "Nearly every observation recorded has been confirmed for *P. rigida*, and *P. austriaca*, and to a large extent for *P. montana* var. *uncinata* and *P. resinosa*." Buchholz (1918) traces the historical development of embryogeny in the conifers and presents a treatment of the embryogeny of *Pinus*. He uses the species *P. banksiana*, *P. laricio*, *P. sylvestris*, and *P. echinata* in his study. Prior to the work of these two investigators, Coulter and Chamberlain (1901), with their researches particularly on *P. laricio*, summarized in their *Morphology of Spermatophytes* the fundamental principles of seed development in the conifers.

Attention is called from time to time in this paper to the general similarities and the discrepancies which are found in a comparison of the seed development of *Pinus palustris* with that known of the other members of the genus. There is also presented a résumé of the major deviations from the *Pinus* type in the seed development of the other genera of the Abietineae.

This study was suggested by and done under the direction of Dr. W. C. Coker, to whom the writer wishes to express his gratitude for encouragement and helpful advice.

METHODS

The male cones were collected from a tree in the Coker Arboretum at the University of North Carolina, brought into the laboratory and immediately killed and fixed. The fresh female cones were packed in damp cotton and sent in boxes from Magnolia, N. C., to Chapel Hill. The delayed fixing of the female cones resulted in the obtainment of only a very small number of mitoses. The killing and fixing fluid used was chiefly chromo-acetic-osmic solution, according to the formula used by Ferguson. With the exception of the stages shown in figs. 77 and 78, the material used in the embryogeny study was likewise killed and fixed in this same fluid. These embryos in figs. 77 and 78, however, were dissected from fresh material and fixed in formal alcohol, as used by Buchholz.

The principal stain used for the study of the mitoses of the microspore-mother-cell was extremely dilute gentian-violet for a long period of time (see Ferguson). The stain chiefly used for the remainder of the microtome sections was Haidenhain's iron-alum haematoxylin with orange G as a counter-stain. The dissected young embryos were stained with Delafield's haematoxylin and mounted in diaphane, as suggested by Buchholz (1926b). For obtaining the whole archegonial membrane, the seeds were macerated by Schulze's maceration process,[1] the membrane teased out, stained in Delafield's haematoxylin and mounted in balsam.

THE STAMINATE CONE

The staminate cones appear in the late fall, but were first collected on December 11, 1929, at which time the primitive archesporium was well developed. The microspore-mother-cells are mature and ready to enter upon their very complicated nuclear activity, meiosis, just after the middle of February (fig. 1).

With the exception of three points, microsporogenesis and the development of the mature pollen grain in *Pinus palustris* agree perfectly with the account given by Ferguson for these phenomena in *P. strobus*, etc. (figs. 1–29). These points are: (1) The thickness of the microsporangial wall, (2) the formation in many cases of a cell-plate between the two biconvex daughter nuclei after the first meiotic mitosis, and (3) the manner in which the microspores are liberated from the microspore-mother-cell.

[1] Youngken, H. W., Pharmaceutical Botany, 5th ed., p. 46.

The microsporangial wall in *P. palustris* consists of from four to five layers of cells and agrees perfectly with that illustrated by Coulter and Chamberlain for *P. laricio*. The tapetum is here considered a layer apart from the microsporangial wall and seems to be derived from the outer layer of the sporogenous tissue. Ferguson states that the microsporangial wall in the pines which she investigated consists of from three to four layers of cells.

A small majority of the mother-cells observed at the close of the first meiotic mitosis in microsporogenesis contains resting daughter-nuclei of a biconvex shape and a very distinct cell-plate at the usual point on the spindle (fig. 13). But in many cases these daughter nuclei are plano-convex and have no cell-plate between them. A cell-plate was generally found at this stage by Coker (1903) in *Taxodium*; and Saxton (1929) showed that a permanent wall is sometimes formed at the end of this first meiotic mitosis in *Larix europaea*. This cell-plate in *Pinus palustris* is, however, very soon rendered obscure by a starch accumulation and an apparent increase in the density of the cytoplasm at this point (fig. 14), and it cannot be stated positively whether it is permanent or not.

From these observations on *P. palustris* and apparently from Miss Ferguson's figures, it seems that in *Pinus* many of the pollen grains, perhaps the majority, are not arranged in the mother cell in the form of the usual tetrad but in one plane, a position quite unusual in either bryophytes or cormophytes.

Concerning the manner in which the microspores are liberated from the thick-walled chambers of the microspore-mother-cell, Ferguson says for *Pinus strobus*, etc., "By the growth of the spore, and more especially by expansion of the air-sacs, the spore-mother-wall is ruptured and the spores are set free." A thorough investigation into this matter in *P. palustris* has shown rather convincingly that this condition does not hold in this species. Instead, it seems that the liberation of the spores is accomplished by some sort of digestive process, by which the thick microspore-mother-cell walls entirely disappear or dissolve and leave the microspores in their original positions. The four microspores as a unit are surrounded by the common matrix until the disappearance of this matrix, when the spores become separated and irregularly situated in the microsporangium (figs. 18–21). In only one microsporangium was there found a condition similar to Ferguson's fig. 48, and this one is not regarded as typical.

Typical mature microspore-mother-cells (fig. 1) were found at the

apex of the staminate cones on February 25, 1930, while basally in the same cone stages up to and including the synizesis stage (fig. 4) were also found. The tetrad of microspores is complete, each spore in a separate chamber of the remarkably thick-walled microspore-mother-cell about March 10th, or about 15 days after the prophase of the first meiotic mitosis (fig. 18). About 15 days later the three divisions of the primary microspore occur in rapid succession, resulting in the formation of the two vestigial prothallial cells, the generative and the tube cells, all of which are present in the mature pollen grain (fig. 29). Regarding the cellular content of the mature pollen grain in the Abietineae, Smith (1923) states that only *Pseudotsuga* agrees with *Pinus*; but according to Hutchinson (1917), *Keteleeria fortunei* also agrees with *Pinus*. In the typical mature pollen grain of the Abietineae, then, Smith states that the generative cell has already divided to form the body and stalk cells, thereby making a total of *five* cells in the mature grain instead of *four* as in *Pinus*.

Although the chromosomes in the meiosis of microsporogenesis are relatively very large, they are rather crowded, and a definite count of the number is difficult to make. Twelve chromosomes have been reported as the reduced number in several pines and some other members of the Pinaceae by several investigators, and this number is certainly very close to, and very probably identical with, the reduced number in *Pinus palustris*. An observation made on the metaphase of the division of the generative cell (fig. 31) seems to confirm this point.

While the primary microspore is undergoing the three above mentioned divisions, the large vacuoles in the cytoplasm begin to diminish in size but become much more numerous. Finally, they begin to vanish, and starch grains appear so that the cytoplasm of the mature pollen grain displays a very delicate reticulation, totally devoid of vacuoles, but with a rich starch content (fig. 29). The size of the average mature pollen grain of *P. palustris* in the fixed condition is 80 microns from the tip of one air-sac to the tip of the other and 42 microns in the median dorso-ventral plane. From a comparative study of the camera lucida figures of the mature pollen grains of *P. strobus* (Ferguson) and *P. palustris*, there is very close agreement in the sizes, and it is probable that the grains of the other pines would also agree in this respect.

Pollination occurred in *P. palustris* about April 11th in 1930 in Chapel Hill, N. C.

THE MALE GAMETOPHYTE

Although the germination of the pollen grain and the development of the male gametophyte were not studied in much detail, it is very evident that these agree closely with Ferguson's account of the corresponding phenomena in *P. strobus*, etc. (see figs. 30–37 of this paper).

The division of the generative cell (figs. 31 and 32) takes place early in March, but there is much variation in the time of this division, as was also shown by Ferguson for *P. austriaca*. The division of the body cell (fig. 35) occurs a little earlier than that of the central cell of the archegonium. Coker (1903) found these two divisions simultaneous in *Taxodium*. The body cell nucleus in *P. palustris* divides 7–10 days before fertilization and nearly 14 months after pollination. Its division results in the formation of two unequal nuclei both of which are surrounded by a common protoplast (figs. 36 and 37). This agrees with Ferguson's (1904) observations on other species of *Pinus*. Reviewing our present knowledge on this point, it is seen that in the majority of the Taxaceae the body cell divides into two unequal sperm cells, only the larger of which functions in fertilization. Likewise, in the Araucarineae of the Pinaceae two sperm cells of unequal size are formed. It seems to be typical of the Abietineae to have two sperm-nuclei of unequal size inclosed in one protoplast, the larger of which is in advance of the other and is the functional one. *Sciadopitys verticillata* (Lawson, 1910) agrees with the Abietineae on this point, but in the other known members of the Taxodineae and those of the Cupressineae the body cell divides into two sperm cells of equal size, both of which may function.

An interesting point here is the change or changes in the amount of starch content from the young microspore-mother-cell stage to the mature male gametophyte just piror to fertilization. In *P. palustris* starch grains first begin to show up in the cytoplasm of the microspore-mother-cell during the late synizesis stage and, as stated above, are quite abundant in the mature pollen grain. This observation is in accord with that of Ferguson on this point. But between the thick-walled tetrad stage of the microspores and the beginning of the three divisions of the microspore to form the mature pollen grain there seems to be a marked diminution in the amount, if not a total absence of starch. Coker (1903) shows that in *Taxodium* "the starch begins to disappear during the second division of the pollen-mother-cell, and is completely used up during the formation of the exine of the pollen-grains. . . . ." There is, then, a total absence of starch in the mature pollen grain and pollen tube of *Taxodium* until it shows up again in the cytoplasm of the

body cell. The starch seems to be restricted to the protoplasts of the sperm cells in the mature male gametophyte of *Taxodium* and probably in the Cupressineae (see Coker, 1903). In *P. palustris,* however, as was also shown by Ferguson for *P. strobus,* etc., there is an abundance of starch present during the entire course of the development of the male gametophyte, both in the protoplast of the bi-nucleate sperm-cell and in the cytoplasm of the pollen tube.

THE OVULATE CONE

The ovulate cones are first noticeable early in March, about 18 months before the ripening of the seeds. At the end of the first season of growth the young female gametophyte has acquired its central vacuole which is quite large, and at mid-winter 8, 16, and 32 free nuclei were counted in its parietal layer of cytoplasm. The details of megasporogenesis were not studied, but the general facts of the development leading up to the formation of the cellular female gametophyte in *P. palustris* (figs. 38–47) are in accord with Ferguson's description for *P. strobus,* etc. One point of deviation, however, is the presence of a thick megaspore membrane, which is very noticeable in the free-nucleate stage of the female gametophyte (figs. 41, 44, 47 and 48). It persists even when the gametophyte contains young embryos in its micropylar end. This condition was also described by Thomson (1905) for *P. resinosa, P. strobus, P. sylvestris,* and *P. austriaca.* According to Thomson, this membrane is "distinctly double," the inner layer of which he calls the endosporium and the outer the exosporium. Coker found pits in the megaspore membrane in *Taxodium.* In commenting on Coker's observations Thomson says that in his study of the ripe seeds of *T. distichum,* the only material he had for study, this observation held for the exosporium but not for the endosporium, and that the "pits" are really irregular spaces around the fibrillae of this layer.

DEVELOPMENT OF THE ARCHEGONIA

The archegonial initials first became apparent on May 9th in 1930 (fig. 48). The female gametophytic tissue grows peripherally upward and about the initials as in *P. strobus* (Ferguson), but in *P. palustris* the channels left above the young archegonia are practically entirely closed, due to the continued growth of the female gametophytic tissue (fig. 56), and do not remain as open channels "leading from the neck-cells to the nucellar cap," as in *P. strobus.* These channels are apparently much longer in *P. palustris* than in *P. strobus.* Also, the arche-

gonium is more elongated (figs. 50, 56, and 61) than shown by Ferguson for *P. strobus*.

As in *P. strobus*, the typical archegonial neck in *P. palustris* is composed of 4 cells, all lying in the same (transverse) plane; but typically each of these cells is decidedly pyramidal in shape (figs. 53 and 56), a condition not shown by Ferguson.

The other facts of this developmental phase in *P. palustris* are in accord with those described by Ferguson for *P. strobus*, etc. (see figs. 48, 49, 50, and 53 of this paper).

FORMATION OF THE VENTRAL CANAL CELL, THE DEVELOPMENT OF THE EGG NUCLEUS, AND FERTILIZATION

In general, these three phases in *P. palustris* agree with Ferguson's account for *P. strobus* (see figs. 53–59 of this paper).

Attention is here called to a condition which has been somewhat overlooked for *Pinus* since Goroschankin's (1883) work on the pines, *P. cembra*, *P. sylvestris*, *P. strobus*, *P. pumilio*, *P. sambiniana*, *P. pinea*, and many other gymnosperms. Just before the ventral canal cell is cut off, very distinct pits can be observed in the wall membrane of the archegonium or central cell in *P. palustris* (figs. 51 and 52). The membrane of these pits has reticulated thickenings of diminishing magnitude down to the point of imperceptibility (with ordinary cytological equipment). Continuity of the protoplasm of the jacket cells and that of the egg was not observable. Also, torn edges of the membrane reveal an uninterrupted continuity of the extremely thin and delicate membrane in the regions of the reticulated pits (Fig. 52). It seems to be incorrect therefore to consider these pits homologous with the sieve-plates of the dicotyledons, as did Goroschankin. Goroschankin conclusively demonstrated open pores in the archegonial membrane of the cyads, but was apparently wrong in considering the pits in the archegonial membrane of the pines as actual perforations. Ikeno (1898) showed pores in the archegonial membrane of *Cycas revoluta*, and other investigators have confirmed these observations of Goroschankin and Ikeno. Ferguson found the archegonial wall in *P. strobus*, etc., to be "very thin" and "scarcely differentiated from the ectoplasm" of the egg. Coulter and Chamberlain (1901) based their description of this wall on the work of Goroschankin.

In 1904, Miss Smith threw much new light on the nutrition and the related morphology in the egg of *Zamia*, and Chamberlain (1906) added to her observations by showing similar conditions in *Dioon*, *Ceratozamia*,

Cycas, and *Encephalartos*. Smith states that at about the time of the maturity of the central cell "the inner walls of the jacket cells become very much thickened and are pierced by numerous pores of various sizes. . . . . Through these pits the protoplasm of the egg protrudes into the jacket cells, forming haustoria-like processes." She further explains that these "haustoria" become knob-shaped and behave like gland cells by their accumulation of nutritive material from the jacket cells and finally discharging this into the central cell, or egg, cytoplasm. Chamberlain's figures are strikingly similar to Smith's, but his explanation of the nutrition differs somewhat from that of Smith. He states that the changes which occur in the jacket cells "and their nuclei resemble those which occur in glandular cells, there being a period of accumulation, followed by discharge, and then exhaustion, after which the processes are repeated." He states further that the jacket cell "nucleus is particularly active" and that "material passes from the nucleus into the cytoplasm and from the cytoplasm into the haustoria. Once within the haustoria, the food materials are already within the egg." It seems, therefore, that the exact function of the haustoria is left a bit vague. Chamberlain's account also differs from Smith's in his explanation of the secondary thickening as occurring on the inner surface of the central cell wall, interrupted only by the characteristic pits, instead of in the inner walls of the jacket cells. My observations on this point in *P. palustris* agree with Chamberlain's description.

The ventral canal cell was cut off about June 7th in 1930 (figs. 53–55), and fertilization took place about June 14th in the year 1929 (figs. 57 and 59). The pollen tube may or may not penetrate the female gametophytic tissue along the exact line of the closed channel above the archegonium, but it closely approximates this locus. The pollen tube continues its digesting of tissue, as begun in the nucellar cap, through the female gametophyte until the egg is reached (figs. 57, 58 and 61). This seems to be the first time such a condition has been described in a gymnosperm.

The average size of the mature egg of *P. palustris* in the fixed condition is 0.71 mm. in the micropylar-chalazal plane by 0.33 mm. wide at the mid-point. There is close agreement between these dimensions and the total dimensions in Ferguson's illustrations, although, as mentioned above, the shape of the egg in *P. strobus* is somewhat more spherical than that of *P. palustris*.

THE EMBRYO

Pinus palustris is in strict accord with *P. strobus*, etc., (Ferguson) in regard to the early proembryogeny (figs. 60–67) and with *P. banksiana*, etc., (Buchholz) in regard to embryogeny (figs. 68–78). Buchholz shows that in *Pinus* eight early embryos are commonly formed from a single zygote. One of each of four of these is formed from the apical cell at the distal end of each of the four suspensors. These are the primary embryos. Then, each of the four rosette cells commonly produces an embryo (see figs. 72 and 73 of this paper). However, the one of all the primary embryos of the ovule, which becomes most vigorous in its growth and furthest advanced downward through the female gametophyte, becomes the final mature embryo of the seed (see figs. 71, 76, 77 and 78 of this paper). The rosette embryos and the other primary embryos are always aborted and finally absorbed by the successful one.

SUMMARY

The major features in the development of the seed of *Pinus palustris* are in accord with those already reported for *Pinus*. The points of major interest because of their deviation to a greater or lesser degree from the accounts already given are:

1. The microsporangial wall consists of four to five layers of cells, the tapetum being considered a layer apart from the wall.

2. In microsporogenesis, in a small majority of the cases, a cell-plate is formed between the two biconvex-shaped daughter-nuclei after the first meiotic mitosis.

3. The liberation of the microspores appears to be accomplished essentially by a digestive action on the microspore-mother-cell wall.

4. There is present a thick megaspore membrane which persists to surround the cellular female gametophyte even when it contains young embryos.

5. There is present a thick archegonial wall which contains numerous pits. The very thin, delicate membrane of these pits has reticulated thickenings on it. Each pit is sub-divided by large, moderately thick reticulations, each of which is further sub-divided by smaller and thinner reticulations, etc., to the point of imperceptibility.

6. The pollen tube may or may not penetrate the female gametophyte along the exact line of the long and practically entirely closed channel in the gametophyte just above the archegonial neck. The pollen tube therefore continues to digest tissue through the female gametophyte until the egg is reached.

7. The archegonial neck is composed of a tier of four pyramidal cells.

As there is no concise statement comparing the structure and development of the gametophytes and embryos of the Abietineae, the following is included for the convenience of students:

I. Grouping of the Abietineae with respect to (1) the cellular content in the mature pollen grain and (2) the presence or absence of air-sacs in the mature pollen grain:

(1) The cellular content of the mature pollen grain.

(a) Those members whose mature pollen grains commonly contain five cells, i.e., two vestigial prothallial cells, the body, stalk and tube cells:

(1) *Cedrus atlantica* (Smith, 1923)
(2) *Larix europaea* (Strassburger, 1892; Coker, 1904)[2,3]
(3) *Pseudolarix kaempferi* (Miyake and Yasui, 1911)
(4) *Picea canadensis* (Hutchinson, 1915)[2]
(5) *Tsuga* [According to Smith (1923). Only statement; no proof.]
(6) *Abies balsamea* (Hutchinson, 1914)[2]

(b) Those members whose mature pollen grains commonly contain only four cells, i.e., two vestigial prothallial cells, the generative and tube cells:

(1) *Pinus laricio* (Coulter and Chamberlain, 1901); *P. strobus*, etc. (Ferguson, 1904); and *P. palustris*.
(2) *Pseudotsuga douglasii* (Lawson, 1909)
(3) *Keteleeria fortunei* (Hutchinson, 1917)[4]

(c) In spite of great variation in the cellular content of the mature pollen grain of *Picea excelsa*, there is generally formed only one prothallial cell, in addition to which the remaining cellular condition is as in (a) above (Pollock, 1906).

(2) Air-sacs (almost always two) are present on the pollen grains in the great majority of the Abietineae. So far as is known at present they are lacking only in the following: All species of *Larix;* all species of *Tsuga* except *T. pattoniana*; and *Pseudotsuga douglasii* (Lawson, 1909). The above facts (except the last) can be found in Engler-Prantl, Die Natürliche Pflanzenfamilien, 2nd edition, vol. 13, and confirmed in a number of cases by special papers on the species.

Among the other conifers, only the pollen grains of the Podocarpineae are known to possess air-sacs. The pollen grains of some of these podocarps, i.e., *Microcachrys tetragona* and *Pherosphaera*

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[2] There is much variation from the typical.

[3] Coker (fig. 10) shows only one prothallial cell, but one may have been missed.

[4] Smith makes a mistake in saying that Hutchinson reports five nuclei in *K. fortunei*. He reports only four.

(Lawson, 1923), possess three small, symmetrically arranged air-sacs.

II. Miscellaneous Points

(1) *Cedrus atlantica* (Smith, 1923)

(a) There is a suggestion of a possibility of parthenogenesis.

(b) A very definite and persistent ventral canal cell is formed and frequently discharges a part of its nuclear matter into the egg, thus giving rise to supernumerary nuclei in the latter.

(c) The cells of the neck are irregularly arranged, the walls often running obliquely; and these cells generally become multinucleate.

(2) *Pinus pinaster*

Saxton (1909) found an occasional case of parthenogenesis in *P. pinaster*.

(3) *Larix europaea*

(a) There is a stigmatic flap formed on the ovules by the extension of that side of the integument which is located toward the cone-axis. This curls over the micropyle like a hood and is of very definite stigmatic function. Finally the flap curls in on itself to introduce the pollen into the micropylar canal (Doyle, 1927; Saxton, 1930; and earlier observers).

(b) A permanent wall is sometimes formed between the two daughter cells at the end of the first meiotic division in microsporogenesis, while at other times the wall does not appear until the second division (Saxton, 1929).

(c) A two-layered tapetum occurs at certain points around the archegonium in the young stages, but this two-layered condition is lost in the later stages (Smolska, 1927).

(d) In *Larix*, only one embryo is formed from each zygote. The rosette cells are only vestigial embryo initials which collapse very early (Buchholz, 1926).

(4) *Pseudolarix kaempferi* (Miyake and Yasui, 1911)

The archegonial neck is usually composed of two tiers of four cells each. This is also shown to be the usual condition in *Pinus austriaca* and *P. rigida* (Ferguson, 1904).

(5) *Picea*

(a) *Picea canadensis* (Hutchinson, 1915)

Occasionally there are formed two functioning antheridial (generative) cells, resulting in a bi-antheridial gametophyte. For a similar case see *Abies balsamea* below. It is interesting to note here that in the pollen tube of *Microcycas calocoma* there are commonly formed 16 active sperm-cells. (Caldwell, O. W. *Microcycas calocoma*. Bot. Gaz. **44**: 118. 1907.)

(b) *Picea excelsa*

The archegonial neck is composed of four to eight rows of cells with two to four cells in each row (Miyake, 1903a).

(c) In *Picea*, as in *Larix*, only one embryo is formed from each zygote.

The rosette cells are only vestigial embryo initials which collapse very early (Buchholz, 1926).

(6) *Tsuga canadensis*

(a) The archegonial neck is most commonly composed of two cells; although in very many cases, the neck initial cell fails to divide at all. Three and four cells are less commonly observed (Murrill, 1900).

(b) In *Tsuga* no rosette embryos are formed, the rosette cells aborting in the unicellular stage (Buchholz, 1926).

(7) *Pseudotsuga douglasii*

(a) A peculiar form of micropyle is developed, having a stigmatic surface with hair-like cells at its mouth, whereby the pollen grains fail to reach the apex of the nucellus but are caught at the mouth of the micropyle and there germinate (Lawson, 1909).

(b) The embryo in *Pseudotsuga* has no rosette cells, or if so, it is the tier of rosette cells which elongates regularly as pro-suspensors (Buchholz, 1926).

(8) *Abies balsamea*

(a) There is an excessive prothallial tissue in the male gametophyte. The body cell divides to form equal male nuclei while still within the spore coat. A prothallial cell may develop as an antheridial cell, a bi-antheridial gametophyte resulting.

(b) The mature archegonial neck usually consists of three or four tiers of cells, with four cells in each tier (Miyake, 1903b).

(c) The ventral canal cell is remarkably persistent, and its nucleus may fuse with a sperm nucleus, producing a ventral proembryo (Hutchinson, 1915).

(d) A rudimentary pollen chamber is developed (Hutchinson, 1915).

(e) In *Abies*, generally only one embryo is formed from a zygote, the rosette cells being only vestigial embryo initials which degenerate very early. In a small percentage of the cases investigated, however, the embryo has been found to undergo cleavage (Buchholz, 1926).

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EXPLANATION OF PLATES

The abbreviations used: p.c., prothallial cell or cells; g.c., generative cell; s.g., starch grains; p.t.n., pollen tube nucleus; b.c., body cell; st.c., stalk cell; s.c., sperm-cell; s.n., sperm-nucleus; ov.sc., ovuliferous scale; nuc., nucellus; integ., integument; mic., micropyle; meg., megaspore; m.m.c., megaspore-mother-cell; s.t., spongy tissue; r.c., resin cells; n.c., nucellar cap; m-g., megagametophyte; ov., limit of the ovulary tissue; nuc. 2., nucellus of the second season; r.m., resinous material; m-g.m., megaspore, or megagametophyte membrane; t.c., tapetal cells; a.n., archegonial neck; c.c.n., central cell nucleus; a.m., archegonial membrane; c.c.c., central cell cytoplasm; m-g.c., megagametophyte cells; p.v., proteid vacuoles; v.c.c., ventral canal cell; sp.1, 1st sperm-nucleus; sp.2, 2nd sperm-nucleus; r.v., receptive vacuole; e.n., egg-nucleus; b.p., basal plate; r., rosette cell or tier of cells; s., suspensor cell or complex; $e_{1,2}$, etc., 1st, 2nd, etc. embryonal tube initial or tier; o.t., open tier of cells; m-g.t., megagametophytic tissue; a., apical cell of the developing embryo; r.e. (1), rosette embryo before elongation of its supensor; r.e. (2), rosette embryo after elongation of its suspensor; t.e., terminal embryonic group of cells; a.e., aborting embryos; c.p., cotyledonary primordia; st.t., meristem of the stem tip.

PLATE 6

Fig. 1. A mature microspore-mother-cell, the nucleus with four nucleoli. × 960. Feb. 25, 1930.

Fig. 2. Microspore-mother-cell nucleus just prior to inception of its division. × 960. Feb. 25, 1930.

Fig. 3. Mother-cell nucleus approaching synizesis. × 960. Feb. 25, 1930.

Fig. 4. Synizesis. × 960. Feb. 25, 1930.

Fig. 5. Complete recovery from synizesis, longitudinal splitting and transverse segmentation taking place. × 960. Mar. 2, 1930.

Fig. 6. Strepsinema stage. Chromatic segments after longitudinal splitting are now becoming more or less shortened and interlaced or twisted. × 960. Mar. 7, 1930.

Fig. 7. Diakinesis stage. Chromosomes have attained compact form, and the various pairs, in the haploid number, lie scattered throughout the nucleus. × 960. Mar. 7, 1930.

Fig. 8. Whole microspore-mother-cell, showing distinct chromosomes in reduced number, the cytoplasm rich in starch, and the thickening mother-cell wall. × 960. Mar. 7, 1930.

Fig. 9. Disappearance of the definite nuclear membrane just prior to its transformation into threads of the nuclear spindle, the various forms of the chromatic segments being very evident at this stage. × 960. Mar. 7, 1930.

Figs. 10–12. Meta-, ana-, and telo-phases of the first meiotic mitosis. × 767. Mar. 7, 1930.

Fig. 13. Biconvex daughter-nuclei in the resting condition, and distinct cell-plate at equator of spindle. × 767. Mar. 7, 1930.

Fig. 14. Later condition of fig. 13. × 960. Mar. 11, 1930.

Fig. 15. Chromatic spireme and metaphase of second meiotic mitosis. × 960. Mar. 11, 1930.

Fig. 16. Telophase of practically a bilateral second meiotic mitosis. × 960. Mar. 11, 1930.

Fig. 17. Early resting stage of the microspores. × 960. Mar. 13, 1930.

Fig 18. The four microspores in the four more recently formed, inner, thick walled chambers of the microspore-mother-cell. Outer original wall also here indicated. × 960. Mar. 14, 1930.

Fig. 19. Microspores still within the mother-cell chambers and showing the beginning of the formation of the air-sacs. × 767. Mar. 14, 1930.

Figs. 20 and 21. Tetrads of microspores surrounded by matrix, and the evident liberation of the spores by a digestive process. × 767. Mar. 14, 1930.

Figs. 22 and 23. Young microspores after liberation. Indication of the reticulated thickening of the exine is well seen in fig. 23. × 767. Mar. 14 and 17, 1930.

PLATE 7

Fig. 24. Telophase in the first division of the microspore. The dorsally thickened exine and the inwardly thickened intine are here shown. × 767. April 4, 1930.

Figs. 25–29. Other stages in the formation of the mature pollen grain (fig. 29), showing the decrease in the vacuolation, increase in starch content of the cytoplasm, etc. × 767. Apr. 3–8, 1930.

Fig. 30. Early germination of the pollen grain at tip of the nucellar cap. Pollen tube nucleus just about to enter the pollen tube. × 353. Apr. 15, 1930.

Fig. 31. Metaphase of the division of the generative cell. × 767. Mar. 11, 1930.

Fig. 32. After the division of the generative cell. × 353. Mar. 14, 1930.

Fig. 33. A composite figure of two adjacent sections, showing tip of nucellus at about same stage as fig. 32 with the ramifications of the pollen tube. Arrow at upper left indicates completion of the broken connection in the pollen tube. × 193. Mar. 21, 1930.

PLATE 8

Fig. 34. Tip portion of pollen tube still comparatively high up in the nucellus, after the stalk cell has passed the body cell. × 353. May 9, 1930.

Fig. 35. Early stage in the division of the body cell. The spindle is typically unipolar; the nuclear spindle is giving way, and the spindle fibers are entering the nuclear cavity. × 430. June 7, 1930.

Fig. 36. Tip portion of the pollen tube comparatively high up in the nucellus, after the division of the body cell. Other sections show the lower (first) sperm nucleus to be larger. × 353. June 14, 1929.

Fig. 37. Tip of pollen tube at base of nucellar cap just prior to fertilization. The tube nucleus shows in another section. × 353. June 14, 1929.

Fig. 38. Very young female sporophyll, showing an ovule just prior to the differentiation of the megaspore-mother-cell. × 80. Mar. 28, 1930.

Fig. 39. Outline figure of ovule after differentiation of megaspore-mother-cell. × 80. Apr. 25, 1930.

Fig. 40. Higher magnification of central portion of previous figure, showing details of the megaspore-mother-cell and a spongy tissue cell. × 430.

Fig. 41. Composite figure of two sections of an ovule, showing axial row of megaspores with some of the surrounding spongy tissue. × 430. May 6, 1930.

PLATE 9

Fig. 42. Composite outline figure of three sections of the same sporophyll, showing ovule at about time the megaspore nucleus has become imbedded in the parietal layer of cytoplasm of the megaspore and with the central vacuole of the megaspore beginning to show up rather conspicuously. Only one megaspore nucleus was evident at this time. × 80. May 29, 1930.

Fig. 43. Megaspore of previous figure more highly magnified. × 430.

Fig. 44. Radial section through central portion of an ovule, showing portions of degenerating nucellar tissue (due to digestion), spongy tissue, and free-nucleate female gametophyte with its thick membrane. × 353. May 2, 1930.

Fig. 45. Similar section to previous one, showing early partitioning of the free nuclei and the cytoplasm of the female gametophyte. × 353. May 6, 1930.

Fig. 46. Outline figure of ovule at a later stage of the early cell formation in the female gametophyte. × 43. May 9, 1930.

Fig. 47. Radial portion of above figure more highly magnified. × 353.

Fig. 48. Early archegonial initial with its surrounding jacket cells in the micropylar end of the female gametophyte. × 353. May 9, 1930.

Fig. 49. After the neck initial cell has been cut off from the central cell. × 193. May 16, 1930.

PLATE 10

Fig. 50. Later archegonium, showing the extremely vacuolate cytoplasm of the central cell, and the neck now composed of a tier of 4 cells. × 193. May 23, 1930.

Fig. 51. Radial section of a slightly older archegonium plus a few jacket cells and cells of the adjacent female gametophyte. × 767. May 26, 1930.

Fig. 52. A portion of the archegonial wall in surface view, showing the pits with their reticulated thickenings. × 767.

Fig. 53. Upper third of an archegonium just prior to its cutting off the ventral canal cell from the central cell. The vacuolation of the cytoplasm is apparently decreasing as the number of "proteid vacuoles" in it apparently increases. The characteristic shape of the neck cells is here shown. × 193. June 1, 1930.

Fig. 54. Upper one-third of an archegonium at very late telophase of the cutting off of the ventral canal cell. All except the proteid vacuoles have disappeared from the central cell cytoplasm. × 193 June 7, 1930.

Fig. 55. The egg nucleus moving downward to take up its position at an upper mid-point of the egg cytoplasm, leaving the degenerating ventral canal cell at the narrowed apex of the latter. × 193. June 5, 1930.

Fig. 56. Mature egg. A more typical representation would show a more elongated shape and a narrowed apex of the egg cytoplasm just underneath the archegonial neck, at the tip of which would be located the somewhat crescent-shaped, very darkly staining and apparently indurated ventral canal cell in a very prostrate condition. × 80. June 14, 1930.

Fig. 57. Fertilization. Much of the chromatin material of the first sperm-nucleus seems to have been misplaced due to mechanical action in the preparation. × 193. June 14, 1929.

PLATE 11

Fig. 58. Section of ovule just after fertilization, showing the path of the pollen tube. × 80. June 12, 1930.

Fig. 59. Conjugation of the sexual nuclei, i.e., first sperm nucleus and egg nucleus. × 353. June 14, 1929.

Fig. 60. Metaphase of the first sporophytic division after fertilization. × 353. June 14, 1929.

Fig. 61. A composite figure of four sections of the same ovule, showing four free nuclei just subsequent to the first two sporophytic divisions of the zygote. × 80. June 12, 1930.

Fig. 62. Composite figure of three sections of the same ovule, showing the four above-mentioned nuclei moving downward to take up their basal positions in the zygote cytoplasm. × 80. June 14, 1929.

Fig. 63. Very early proembryo stage after the four free sporophyte nuclei have taken up their basal positions. × 80. June 12, 1930.

Fig. 64. Lower position of the zygote just prior to the first division of the four nuclei which have arranged themselves at the " 'organic apex' of the oosphere" (Ferguson, '04) in a plane transverse to the long axis of the zygote. × 193. June 14, 1930.

Fig. 65. Just after first division of above-mentioned four nuclei to form two tiers of four cells each, those nuclei of the upper tier not being closed in by cell walls. × 193. June 17, 1930.

Fig. 66. Late telophase of the third division of the pro-embryonic tiers of cells, involving the lower-most tier. (The second division involves the uppermost tier of the two resulting from the first division.) × 193. June 7, 1930.

Fig. 67. Early 16-celled proembryo stage before the elongation of the suspensor cells. × 193. June 19, 1930.

PLATE 12

Fig. 68. A composite figure of three sections of the same ovule, showing a sixteen-celled proembryo with the suspensor cells beginning to elongate, and one of the apical cells in the metaphase of cutting off its first embryonal tube initial. × 193. June 17, 1930.

Fig. 69. Later stage of the embryo after the cutting off of the first embryonal tube initial from each apical embryonic cell. Early indication of "basal plate" (Buchholz, 1918). × 43. June 14, 1930.

Fig. 70. Later stage of embryo, showing the basal plate, etc. × 80.

Fig. 71. Semi-diagrammatic figure of the embryo complex dissected as a unit from an ovule. × 23. July 1, 1929.

Fig. 72. Tier of young rosette embryos, view from above × 100.

Fig. 73. Young rosette embryos, one interpreted as having a suspensor which is elongating. × 80. June 20, 1929.

Fig. 74. Young primary embryo group with an apical cell of three cutting faces. × 193. July 20, 1929.

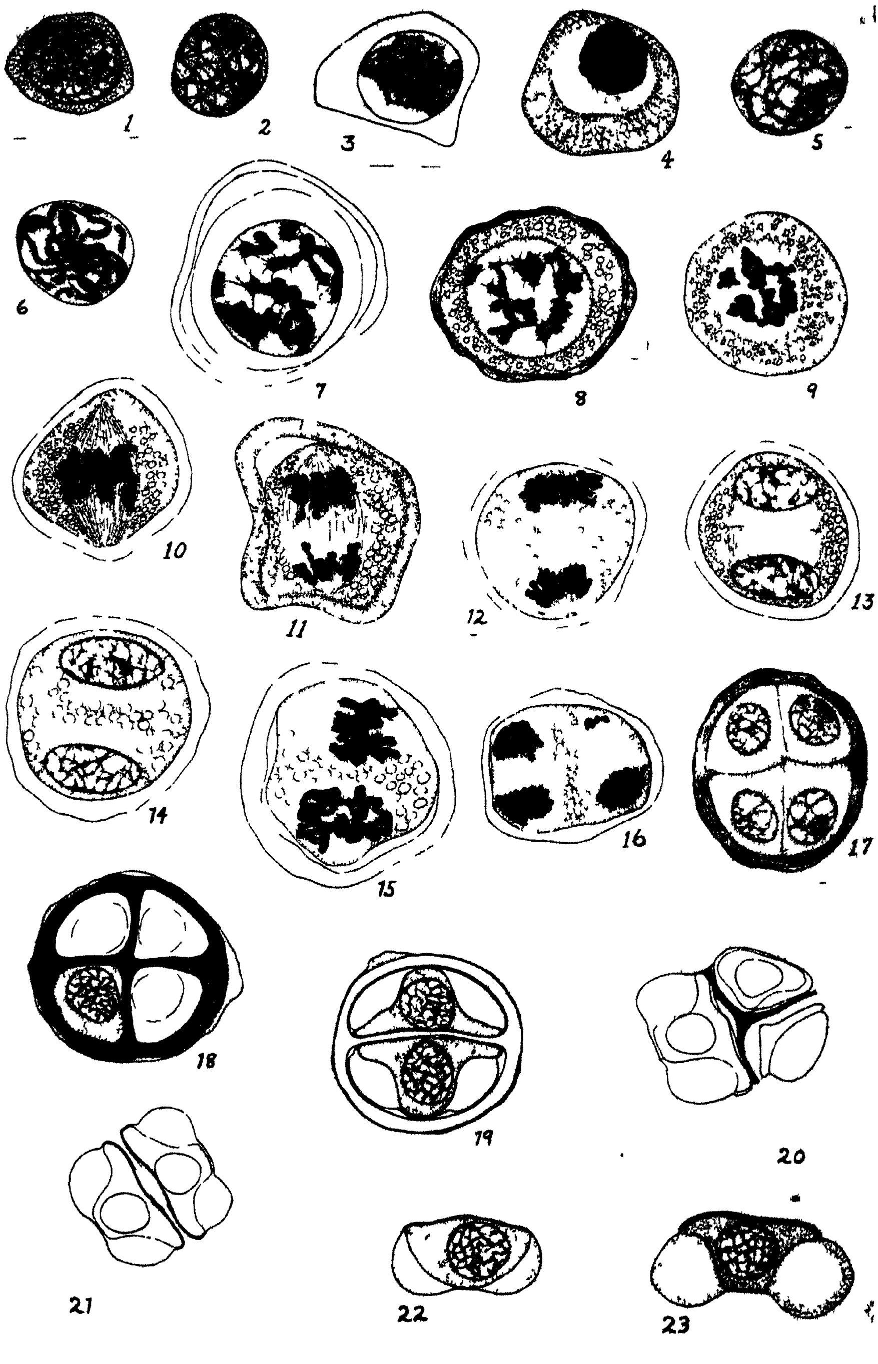
Fig. 75. Later massive embryo with a characteristic secondary suspensor of embryonal tubes of an irregular arrangement, in which suspensor divisions are no longer indicated. The apical cell of three cutting faces has not yet disappeared. × 193. July 20, 1929

Fig. 76. Semi-diagrammatic figure of later embryo complex with full indication of the embryo that will become the final mature seed embryo (t.e.). The apical cell has disappeared in this terminal embryo, and other more basal embryos are seen in more or less abortive condition. × 23. July 20, 1929.

Fig. 77. Later embryo with the first indication of cotyledonary primordia (c.p.) and the meristem of the stem tip (st.t.). × 8. Aug. 8, 1929.

Fig. 78. Mature seven-cotyledonous embryo. × 7. Aug. 20, 1929.

PLATE 6



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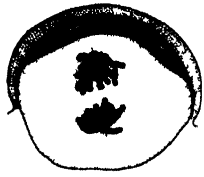

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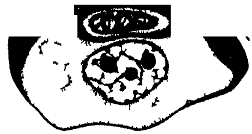

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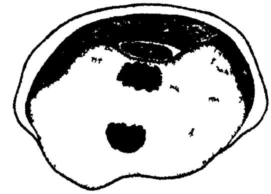

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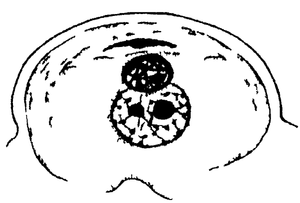

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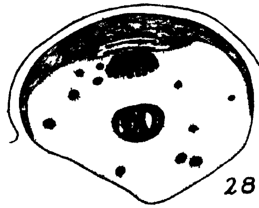

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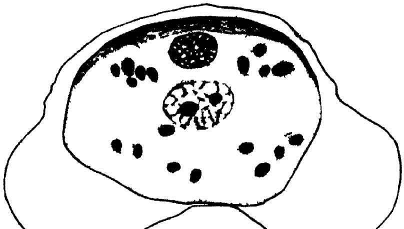

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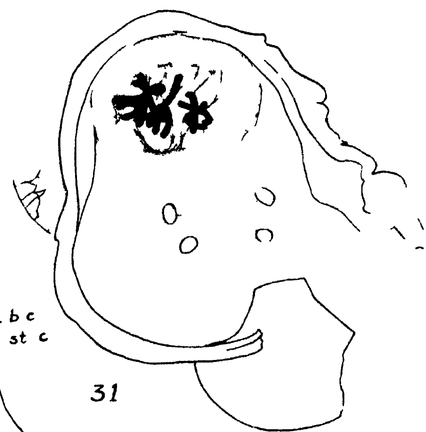

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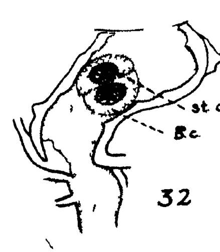

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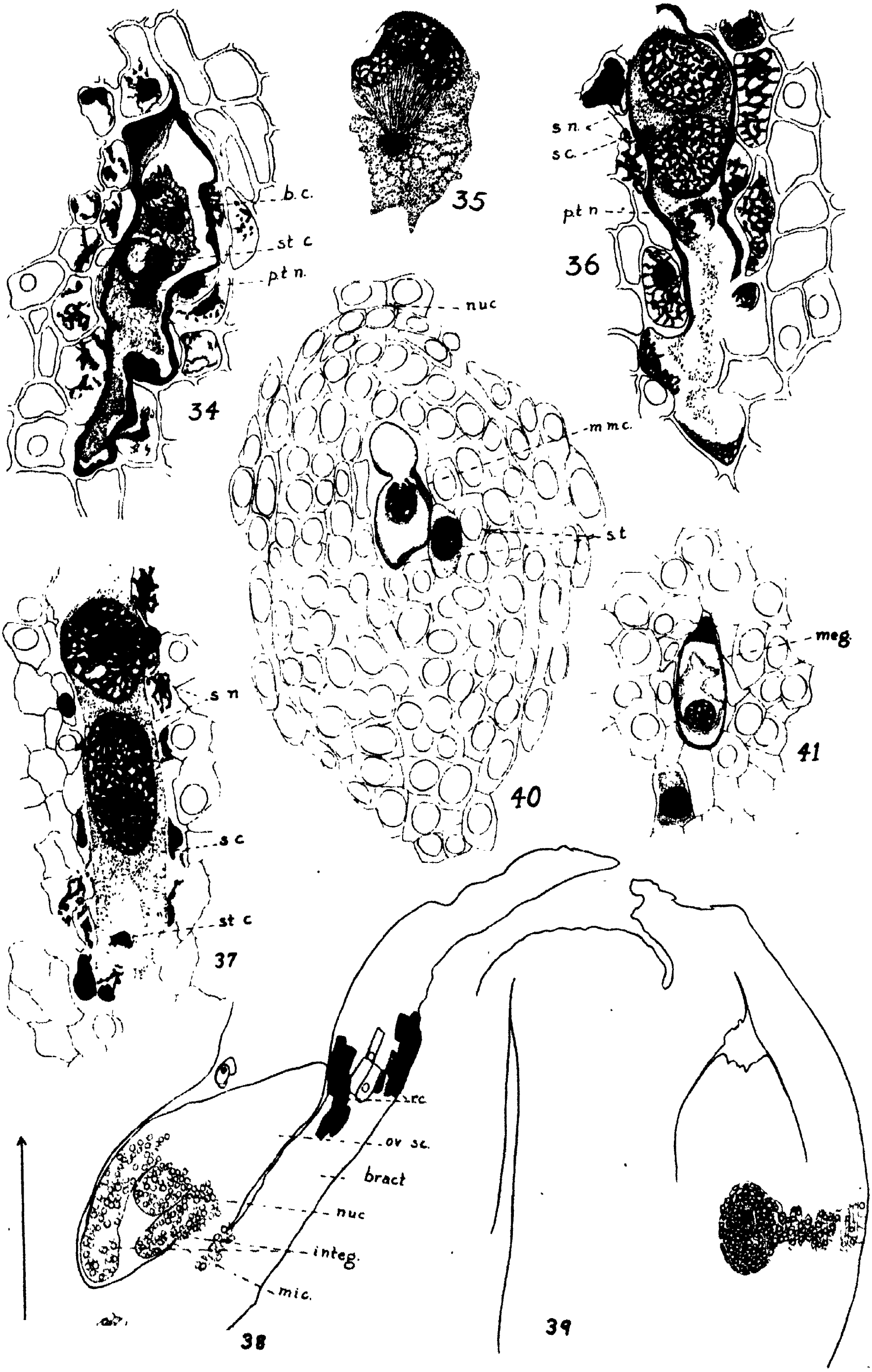

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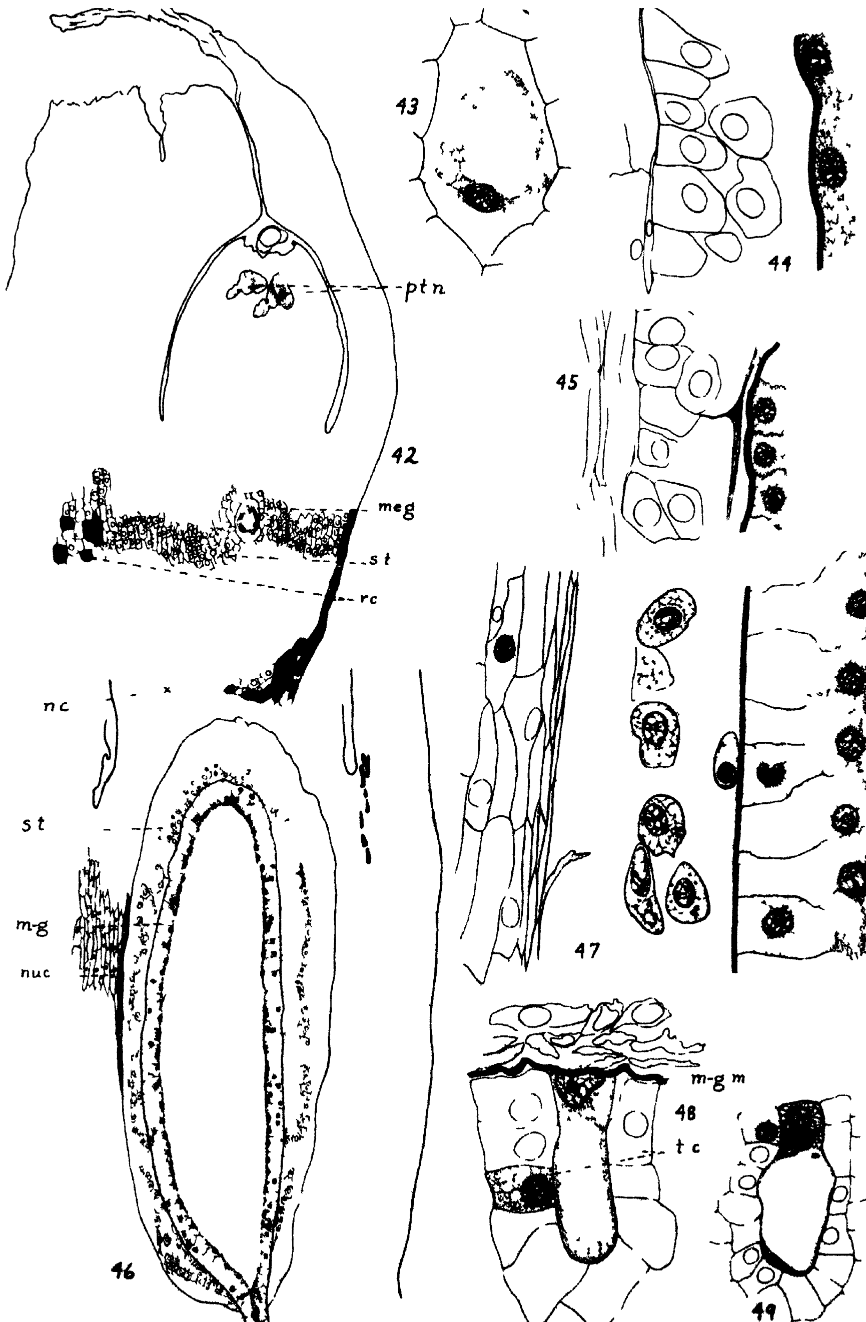
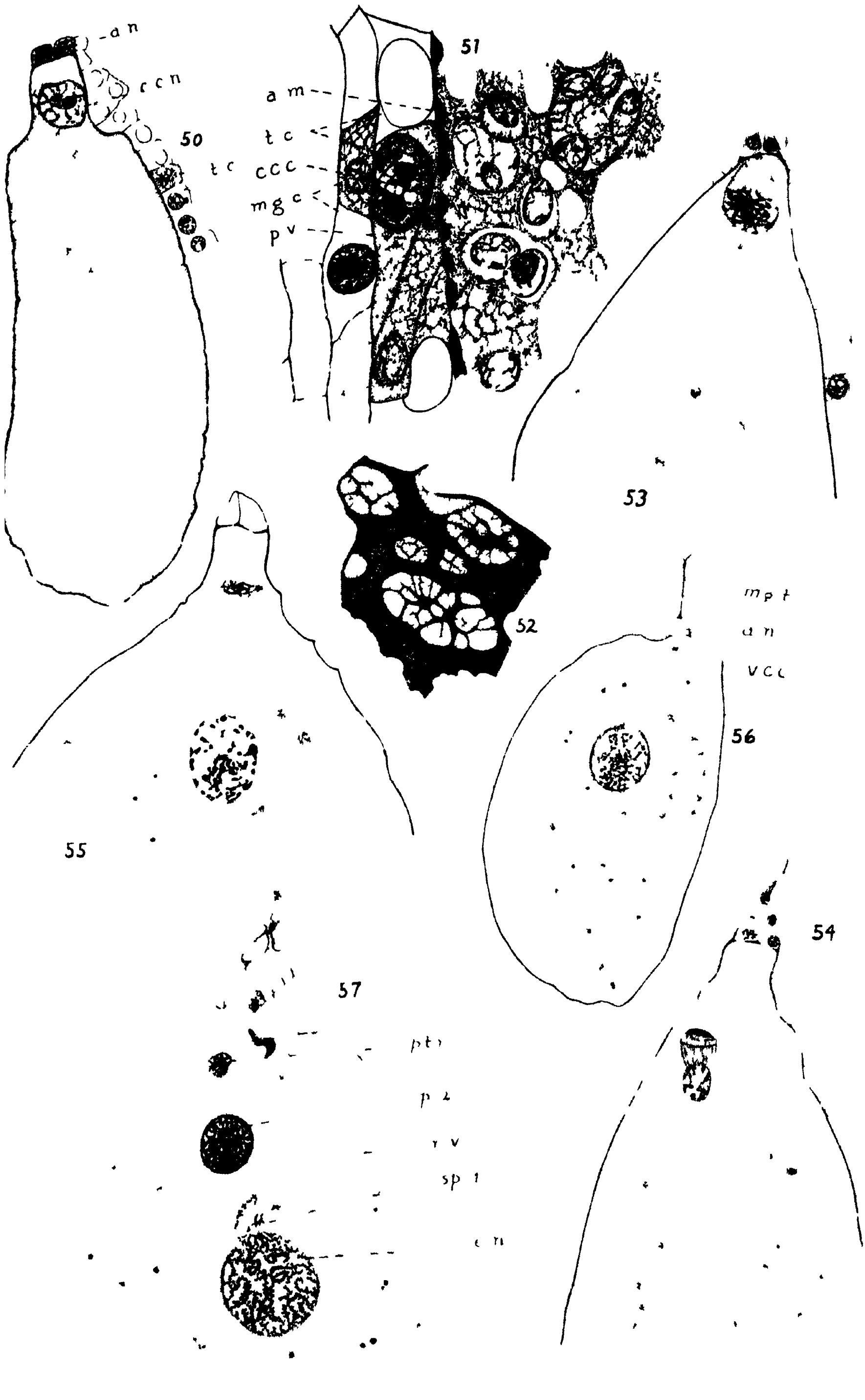
PLATE 9

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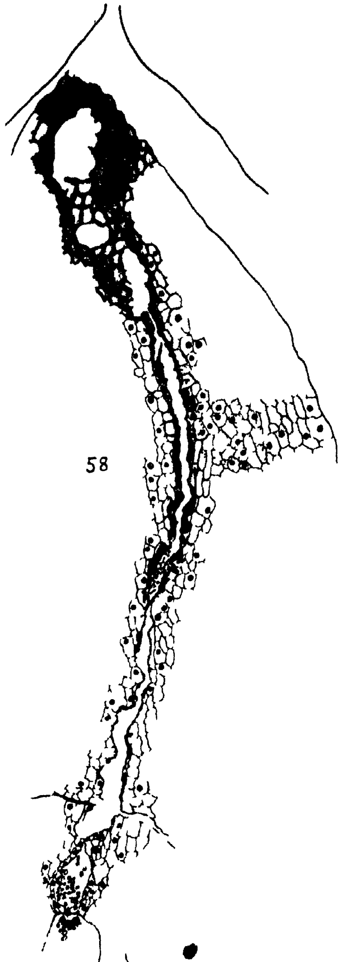

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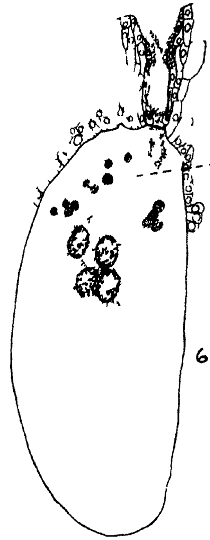

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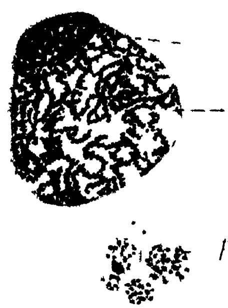

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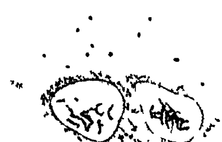

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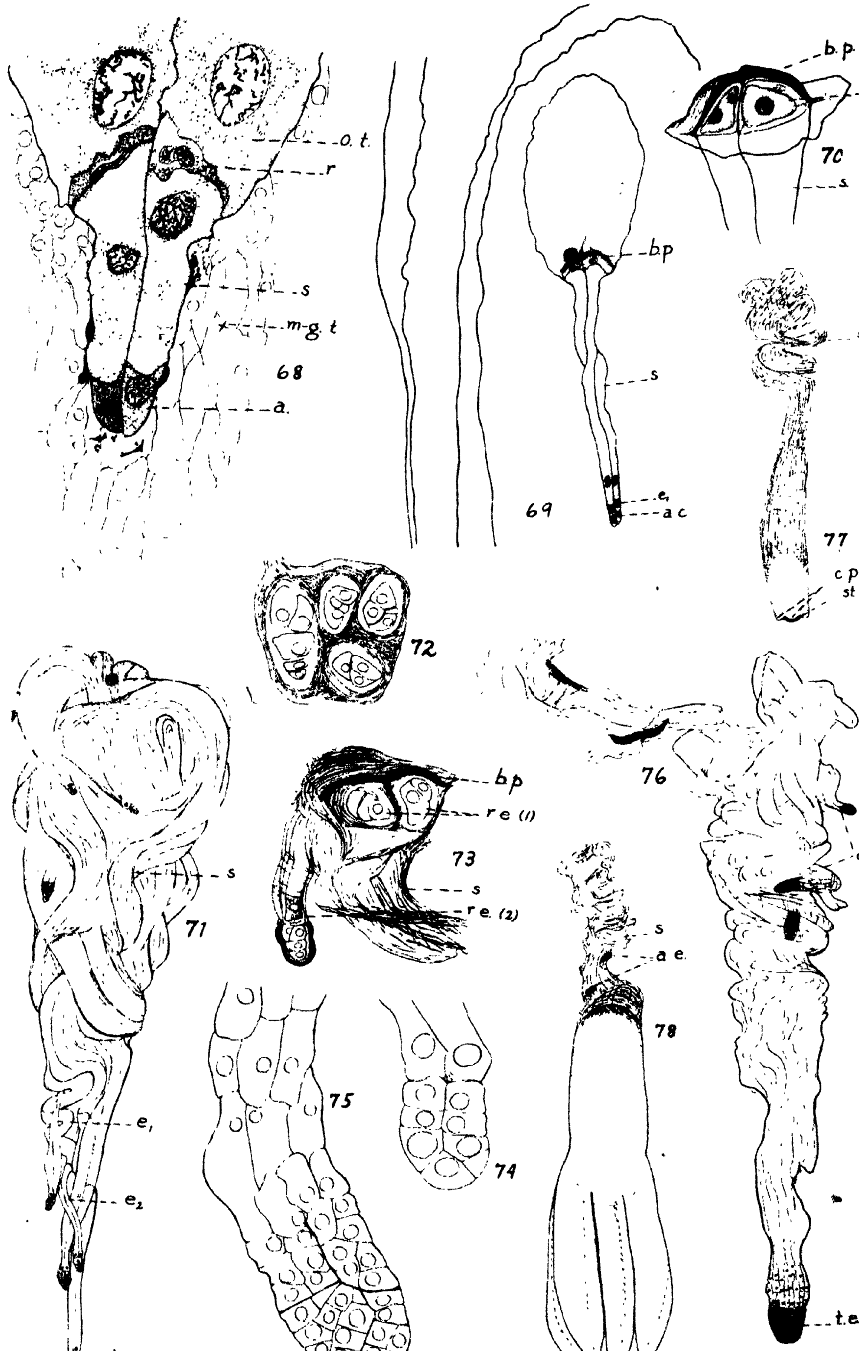
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PEDESTAL ROCKS OF GRANITE IN THE SOUTHERN PIEDMONT

By JULIAN J. PETTY

PLATES 13 AND 14

INTRODUCTION

Pedestal rocks occurring in arid and semi-arid regions have been described by several writers, but pedestal rocks in humid regions have been given very little, if any, attention. There are a number of references to stratified pedestal rocks, but the author has found no references to pedestal rocks composed of homogeneous material and developed in humid climates, with the exception of stacks and similar forms due to the work of waves. Pedestal rocks of unstratified material in humid regions are not abundant or they have not attracted the attention of physiographers.

In arid and semi-arid regions the development of pedestal rocks has been attributed to erosion by drifting sand, but Bryan[1] and later Leonard[2] have shown that these rock monuments have been formed by other processes in the western United States, running water, rainwash, differential weathering, and granular disintegration having been most effective. Thus the presence of pedestal rocks in humid regions can not be taken as evidence of former aridity, since the processes by which they may be formed are common to both arid and humid climates.

PEDESTAL ROCKS IN THE PIEDMONT PLATEAU

The piedmont plateau of the southeastern states commonly has a thick layer of soil and weathered rock, in places 100 to 200 feet thick. Rock exposures are rare, but in areas where granitic intrusions outcrop, the surface is usually boulder-strewn. Associated with these bouldery outcrops in North and South Carolina and Georgia there occur pedestal

[1] Bryan, Kirk. Pedestal Rocks in the Arid Southwest. U. S. G. S. Bull. 760: 1–11. 1925; Pedestal Rocks in Strean Channels. Ibid., pp. 123–130; Pedestal Rocks formed by Differential Erosion. U. S. G. S. Bull. 790: 1–15. 1926.

[2] Leonard, R. J. Pedestal Rocks resulting from Disintegration. Journ. Geol. 35: 469–474. 1927.

and balanced rocks. Similar boulder outcrops are found in many places, but the presence of pedestal rocks is not mentioned in descriptions of these areas.

One of the pedestal rocks most perfect in form lies about 50 yards west of the Columbia-Charlotte road, U. S. Highway 21, at Rockton, about 4 miles south of Winnesboro, South Carolina. This pedestal rock is locally known as Anvil Rock (fig. 2). It is about 10 feet in height, 12 feet across in longest diameter and 6 feet in shortest diameter. The shaft is also oval in plan, with dimensions of about 3 by 6 feet. The upper surface of the rock is hard and smooth, but from the shaft grains may be detached by rubbing. This difference may be due in part to painting of the upper surface for advertisements. Anvil Rock occurs in a boulder area which extends 18 miles to the west and includes the large Anderson Quarry devoted to the production of monumental stone, and the abandoned Rion Quarry. The rock is a medium-grained granite of light-gray color.

The pedestal rock shown in Fig. 1 is located in a cultivated field about 2 miles southwest of Heath Springs, South Carolina, in a boulder area which covers a large part of Lancaster, Kershaw, and Chesterfield Counties. It has a height of 12 feet and is nearly circular in plan, having a diameter of about 8 feet where largest. The granite is coarse-grained and porphyritic.

Several pedestal rocks occur in the granite area north of York, South Carolina. Large boulders are common on the surface where this granite outcrops and many rock masses are undercut at the soil surface or have cave- or pocket-like re-entrants. The pedestal rock shown in Fig. 3 is located two-thirds of a mile northwest of Filbert. It is 12 feet in height and slightly oval in plan, being about 10 by 14 feet in diameter, with a shaft 6 by 8 feet in diameter. The upper surface is fairly smooth, and although the shaft is not as smooth, the rock is firm. The shaft widens somewhat a few inches above the soil surface, and at this level grains may be easily rubbed off with the hand. The granite is a coarse-grained rock with a porphyritic texture.

Balanced or perched boulders are found frequently in the boulder areas. Several occur in the Rion area.

While no extended field study has been made, it seems evident that the boulder areas visited are more or less typical of such outcrops in the southern piedmont plateau. The pedestal rocks described are exceptional in the perfection of their shape, but many forms less perfect are to be seen in the field. There are several in the granite area near

Concord, North Carolina, and spire-like forms such as "The Pinnacle" on Dunn's Mountain near Salisbury, North Carolina, are closely related. In Georgia pedestal rocks occur near Clinton, Jones County, and balanced boulders in DeKalb County. There are without doubt many other localities not mentioned above where pedestal and balanced rocks occur.

ORIGIN OF THE PEDESTAL ROCKS

These peculiar results of rock weathering may be conveniently divided into two groups, due either to difference in method of origin or to different stages of the same process. In one type the pedestal is an integral part of the mass above and below, no clearcut fractures or changes in rock character having brought about a difference in rate of weathering. To this type belong the pedestal rocks shown in Figs. 1, 2, and 3. In the other type there is a separation of upper and lower parts, the result being a balanced or perched rock. While perched forms may result through the destruction of the pedestal or shaft of such a form as that shown in Fig. 2, they may also be due to more rapid weathering along inclined or horizontal fractures, which thus produces rounded masses that lie one above another. They may, therefore, represent either the remains of former pedestal rocks or boulders of disintegration.

The origin of the type in which the pedestal is an integral part of the mass above and below is not as clear. Their origin has been discussed by Bryan and also by Leonard for the Southwest, but the processes which they regard as dominant hardly apply in the same degree to the pedestal rocks of the southern piedmont.

Chemical decomposition of rocks goes on very rapidly in the southern piedmont due to fairly high temperatures throughout the year and abundant rainfall. As a result, rock exposures are rare. Where rock comes to the surface or above, chemical weathering is most rapid near the soil surface where conditions are most favorable. Decaying vegetation furnishes humic acids; moisture is more abundant due to protection afforded by vegetation and capillary rise of water from below. The atmosphere would normally dry the upper surface of a rock long before it would the portion near the soil level. Dampness promotes chemical decomposition, especially hydration,[3] and thus any projecting rock mass would tend to be undermined at or near the soil surface, and under

[3] Blackwelder, E. Cavernous Rock Surfaces of the Desert. Amer. Journ. Sci., 5th ser., 17: 393–399. 1929.

favorable conditions develop into a pedestal rock. Horizontal fractures or differences in rock resistance are not essential for the development of this type, but if present would tend to increase the rate of undermining, thus forming more quickly the balanced or perched boulder. It seems evident that some vertical fractures are necessary to afford lines along which more rapid downward weathering can take place. If reduction of soil level is uniform, undercutting may not take place, and thus spires, such as "The Pinnacle" and other projecting masses on Dunn's Mountain, result.

The surface of the projecting rock masses and boulders is generally covered with lichens, growing on an iron-stained crust an inch or two in thickness. The boulders are but slowly destroyed, perhaps because the iron-stained crust protects the rock to a certain extent from spalling, and the lichens, while they promote chemical weathering, may also help to protect the rock from rapid temperature changes.

The more rapid rotting of posts at the soil surface is too well-known to require comment. Evidence of an increased rate of weathering of rocks is found in numerous rock masses undercut at this level. A few feet from Anvil Rock is another projecting rock mass with well-defined undercut (Fig. 4). The upper surface of the rock is smooth and firm whereas the rock in the undercut is decayed and easily broken. A partial analysis of this weathered material, compared with a similar analysis of the unweathered rock, shows a decrease in sodium and potassium, but beyond that a chemical study of the nature of the weathering has not yet been made.

CONCLUSION

It is believed that the pedestal rocks described above are due largely to chemical weathering which acts at or near the soil surface on projecting rock masses. Frost action, granular disintegration, and rainwash may be auxiliary agents, but their activity is made possible or more effective by weakening of the rock through chemical decomposition.

UNIVERSITY OF SOUTH CAROLINA,
COLUMBIA, S. C.

PLATE 13

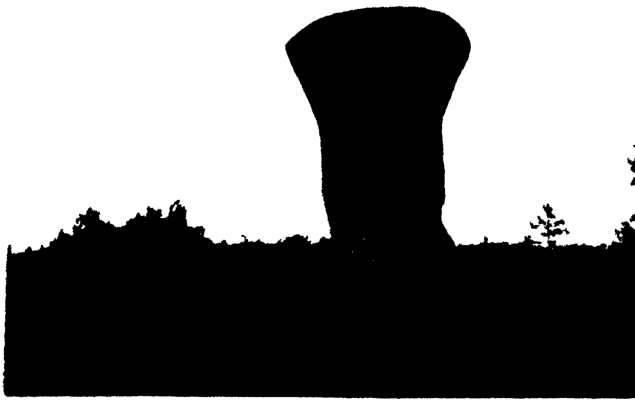

Fig. 1 (above). Pedestal rock 12 feet high near Heath Springs, S C (Photographed in 1931).

Fig. 2 (below). Anvil Rock near Rockton, S C A pedestal rock which is an integral part of the mass below. (Photographed in 1931).

PLATE 14

Fig. 3 (above). Pedestal rock two-thirds of a mile northwest of Filbert, S. C. (Photographed in 1932).

Fig. 4 (below). Undermining at soil surface near Anvil Rock, Rockton, S. C. Note partial covering of rock surface by lichen. (Photographed in 1931).

SOME PRELIMINARY NOTES ON THE ECOLOGY OF THE UPLAND COMMUNITIES IN THE VICINITY OF GREENSBORO

By Earl H. Hall

This, as far as I can determine, is the first attempt at any description of the habitats and communities of the vegetational features found in the piedmont region, especially in Guilford County where preliminary studies are now under way.

The county is considered to be an elevated plateau with an elevation averaging about 850 feet above sea level. The surface is dissected by streams which cause a varied form from gentle rolling to steep broken topography. It is in this smooth to gently rolling portion of the area that I wish to call attention to the forms of vegetation.

This flat area which occupies the northern and central portion of the county is cut into northeasterly trending ridges by the heads of Haw River, Mear's Fork, Reedy Fork, and branches of Buffalo Creek. The southwest central part is drained by the head of Deep River.

The underlying material being very resistant, ravines are not cut until the streams reach a place bounded by a zigzaging line extending from the north boundary line near Brown's Summit, southwestward to the Greensboro water works, eastward almost to McLeansville, and back south and west to Chilton's mill where a definite fall line is traced in the streams' development and consequently a material change is shown in the vegetational features.

The vegetation of the region is classified, according to Wells, as belonging to the climatic formation of the deciduous forest type. The region is characterized by various stages in development toward the climax of the Eastern United States. On account of cultivation and other physical changes the formation is best classified today as being *Syntherisma- Erigeron- Andropogon* formation (Wells) finally ending in *Quercus rubra-Acer saccharum- Fagus grandifolia*. Or if we study this section from an association it falls under the *Quercus- Hicoria*, *Quercus-Castanea* and also the *Acer-Fagus* associations of our eastern deciduous forest formation and in one case it has reached the *Acer-Fagus-Tilia* association. Each of these is preceded by its typical consocies. This

is shown by the fact that where the topography is such that the soil is relatively deep and of fair quality the forests are a mixture of *Quercus alba*, *Quercus rubra*, with scattered *Quercus marilandica*, *Quercus coccinea*, and some *Quercus stellata* intermingled with *Carya ovata*, and *Carya alba* with their associated shrubs and herbs. In this case the *Quercus marilandica*, *Quercus coccinea*, *Quercus stellata*, and *Carya alba* constitute the consociation.

Some of the ridges which are made of a very crystalline form of quartz have become rather sharp. These disintegrate into such a poor grade of soil that one may characterize them as being occupied by a subclimax of *Quercus marilandica*, *Quercus stellata*, *Quercus velutina*, with scattered *Carya ovata*, and some *Quercus alba*. True, these same trees on good soil are really a part of the developmental association, but here on this soil they constitute an edaphic association.

In spite of the highly dendritic drainage of this region, hydrarch associations are scarce or at least only slightly developed in the northwest portion of the county. Not until the streams have acquired many side tributaries do the valleys show the hydrarch types of vegetation. It leaves this area wholly of the xerarch type of development. It is true that the streams hasten the developmental stage toward the climax associations in the immediate vicinity of the stream. The evident character of the hydrarch development is seen in such form as *Acer rubra*, *Acer saccharum*, *Liquidambar styraciflua*, *Fraxinus* species, *Quercus phellos*, *Platanus occidentalis*. This hydrarch developmental association is still to be found in flat areas with a very impervious layer which causes the drainage to be so poor that only the hydrarch members can be maintained. On the edge of these flat, swampy areas near the drained end the climatic forest may be found encroaching upon the developmental types of the hydrarch associations.

Field studies are under way now to determine what correlation there is between soil types and typical associations. Not enough work has been done to warrant any definite conclusions but enough evidence has been obtained to suggest at once that some of the slight differences in soil may be the result of the difference in vegetation. This study will be further developed by facts from vegetational history.

It is needless to say that all the abandoned fields are soon occupied by *Pinus virginiana* or *Pinus echinata*, which are successions in this developmental association.

NORTH CAROLINA COLLEGE FOR WOMEN,
GREENSBORO, N. C.

THE EFFECT OF VARIOUS CHEMICALS ON THE LARVA AND PUPA OF CULEX PIPIENS AT VARIOUS TEMPERATURES

By B. J. BAROODY

This paper presents the results of tests on the resistance of larva and pupa of the mosquito, *Culex pipiens*, Linnaeus, to various dissolved chemicals. The work extended for a period of eight months and control experiments were carried on in connection with each substance studied. The drugs used were: mercuric chloride, copper sulphate, sodium chloride, hydrochloric acid, sulphuric acid, acetic acid, oxalic acid, lactic acid, sodium hydroxide, sodium bicarbonate, ethyl alcohol, formaldehyde, iodine, and finally a chemical mixture which for convenience is called the CMIF Mixture. This mixture contains copper sulphate, mercuric chloride, iodine, and formaldehyde.

Tests were made at three temperatures throughout the experiments: 23°C., 11°C., and 5°C. These temperatures were fairly constant. The 23°C. was room temperature and this never varied over one degree at any time, for the room where the experiments were performed was controlled by an automatic thermoregulator. At 11°C. and 5°C. a refrigerated room and a frigidaire were used.

Distilled water was used for all dilutions and good grades of chemicals were used throughout. Ten individuals, larvae or pupae, were used for each test.

A microscope, usually a binocular, was used in all experiments for the determination of the death point. There has been debate regarding the death points in larval and pupal mosquitoes. One investigator uses the death point as the time when all movements of the body are invisible to the naked eye.* This method is rather inaccurate because there is certainly wide variation in the visible motility of various individuals. The writer has used as a criterion for death the cessation of all pulsating movements within the body. This method certainly does

* Frobisher, M., Jr., and Shannon, R. C. The Comparison of the Effects of Various Substances upon the Larva of *Aedes aegypti*. Am. Jour. Hyg. 14(2): 427. 1931.

not give the exact point of death, but at least gives results which are fairly comparable. The writer has witnessed many recoveries after death had been recorded after loss of visible motility, but no evidence was observed of recovery after visceral pulsations had ceased. Although working with *Culex pipiens*, it has been shown that killing-time results are fairly comparable to the results obtained by Frobisher and Shannon in their work on *Aedes aegypti.*

Experiments were conducted with both larvae and pupae. Size classes were established in the case of the larvae according to length, 2 mm., 3 mm., 4 mm., 5 mm., 6 mm., and 8 mm. larvae were tested. The time in which death occurred was generally in the same order, the larger larvae always resisted chemical action longer than the smaller individuals.

In regard to temperature, the larvae or pupae always died first at 23°C.; lived somewhat longer at 11°C., and longest at 5°C. The length of life was related to size at all temperatures. Another effect of temperature was that the transformation into the next stage was always postponed if the animal was subjected to a lower temperature. For example, if a fourth stage larva in distilled water was placed in a temperature of 5°C., it may live in the larval stage for two or three days, but a larva allowed to remain in distilled water at 23°C. pupated in about twenty-four hours. The same can also be said of the pupa, for low temperatures postpone the adult stage. Most chemicals appear to act like low temperatures in dilute solutions and may prolong the usual life cycle. A larva will pupate more quickly in distilled water at room temperature than it will in a 1% solution of sodium chloride at the same temperature.

The pupa was found to be more resistant to a chemical than the larva in the same concentration of a solution. It has a case or covering which is much heavier than the larval covering, so it would be expected to be more resistant.

The effects of iodine are certainly of great interest and significance. Only aqueous solutions were used. In a saturated solution of iodine a larva always died in about a minute at room temperature, while a pupa in many instances wiggled about for half an hour. In a dilute solution of iodine the larva would still die in a comparatively short time, while the pupa always developed into an adult. In one particular case a pupa was placed in a saturated solution of iodine for 10 minutes, then removed and placed in distilled water, and by the next day it was an adult.

Copper sulphate exhibits toxic properties in a very noticeable manner.

TABLE I

EFFECTS OF CHEMICAL SUBSTANCES ON LARVAE AT 23°C. (ROOM TEMPERATURE)

H = hours. M = minutes. S = seconds. P = pupated

	CONCENTRATIONS, PER CENT																
	100	95	70	40	25	10	5	2.5	1.	.5	.25	.1	.02	.01	.005	.0025	.0006
Mercuric chloride									18M	33M	61M	138M					
Sodium chloride					28M	74M		20H	66H	P							
Copper sulphate						62M	3H	4H	5H	8H							
Sodium hydroxide					7M	16M	19M	25M	33M								
Sodium bicarbonate						1½H	2H	5H	12H								
Acetic acid	20S				18M		48M	68M	90M								
Oxalic acid						10M	17M	30M	50M								
Lactic acid					38M	84M	2H	3H									
Sulphuric acid					12M	34M	58M	85M									
Hydrochloric acid					10M	36M	60M	90M									
Ethyl alcohol		2M	22M			11H											
Formaldehyde				5M		13M	15M	18M	24M	45M							
Iodine													1.2M	3M	7.2M	15M	75M

TABLE II

EFFECTS OF CHEMICAL SUBSTANCES ON PUPAE AT 23°C. (ROOM TEMPERATURE)

H = hours. M = minutes. S = seconds. A = adults emerged

	CONCENTRATIONS, PER CENT																
	100	95	70	40	25	10	5	2.5	1.	.5	.25	.1	.02	.01	.005	.0025	.0006
Mercuric chloride									13H	16H	19H	25H					
Sodium chloride					14H	18H		22H	A	A							
Copper sulphate						4H	10H	17H	21H	30H							
Sodium hydroxide					20M	1H	2H	3H	5H								
Sodium bicarbonate						3H	5H	11H	18H								
Acetic acid	2M				30M		2H	3H	4H								
Oxalic acid						40M	90M	3½H	5H								
Lactic acid					1½H	3H	7H	9H									
Sulphuric acid					20M	1H	1½H	2½H									
Hydrochloric acid					22M	1H	2H	3H									
Ethyl alcohol		6M	42M			20H											
Formaldehyde				8M		35M	65M	1½H	1¾H	2½H							
Iodine													30M	2H	8H	A	A

In 5% or 10% solutions it does not seem to kill larvae any more rapidly than sodium chloride in like percentages of solutions, but as the concentration becomes less copper sulphate still shows toxic properties while sodium chloride appears to be quite innocuous.

Organic acids were much more toxic than inorganic acids in weak concentrations. The organic acids had apparently greater penetrating power.

The effects of sodium hydroxide are shown in Tables I and II. This strong base is very toxic for either larvae or pupae.

Sodium bicarbonate, an example of a very weak base, had little effect, especially in weaker concentrations.

Ethyl alcohol in higher concentrations was quite toxic but lost its potency rather rapidly as the concentration was lessened.

Formaldehyde was very effective as a larvacide. This chemical is known to coagulate protoplasm and mosquito protoplasms were not spared. Its effects were toxic on both larvae and pupae.

By combining copper sulphate, mercuric chloride, iodine and formaldehyde, it was found that quite an effective larvacide was produced (CMIF Mixture). In strong solutions this mixture brings about death almost instantly. In weak concentrations it still showed properties that made it appear to give promise as an effective larvacide. Larvae died rather quickly in concentrations as low as .0004%. The writer expects to make further tests on the effects of mixtures of toxic chemicals on mosquito larvae and pupae.

CONCLUSIONS

1. In solutions of chemicals, death of larval and pupal mosquitoes occurs more quickly at higher temperatures than at lower. Tests made at 23°C., 11°C., and 5°C.

2. Lowering of temperature postpones transformation into the next stage.

3. Larger larvae are more resistant than those of smaller size.

4. Pupae are more resistant than larvae; probably because of tougher covering.

5. Iodine quite effective as an insecticide against larvae but not against pupae.

6. A 0.0004% mixture of copper sulphate, mercuric chloride, iodine, and formaldehyde kills larvae and pupae overnight. This CMIF Mixture has possibilities of becoming an effective larvacide.

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CAUSES AND PREVENTION OF CORROSION IN GAS MAINS

By E. E. Randolph and J. M. Morrow

This work is part of a corrosion study program undertaken by the Chemical Engineering department extending over a period of several years, originally a coöperative program with the State Highway Commission, but gradually branching out into many fields.

There are 32 plants in the state for making artificial gas, eleven of which make coal gas and have blue gas standby sets. The daily make of the larger plants averages from 500,000 cu. ft. to 700,000 cu. ft. The leakage of gas from the mains of these companies varies from 9 to 15% of the make. A monthly leakage therefore of 1,350,000 cu. ft. at $1.80 per thousand makes a monthly loss of $2,430 which must be sustained by the company.

Although the leakage is a heavy economic loss, it is only a part of the loss. In the City of Raleigh with 40,000 people there are 94 miles of three inch equivalent gas mains. Practically all of the mains and part of the service pipes are under paved streets. It is expensive to discover leaks under paved streets, replace the pipes, and repair the streets. This problem is still more complicated by the water mains and service lines, by the sanitary and storm sewers, by the telephone lines, and by the street car lines.

In this connection a careful study of the most important theories of corrosion would include among others the oxidation theory, the decomposition of water or the hydrolysis theory, the acid theory, and the electrochemical theory.

Our investigations show the following positive corrosive agencies within the gas lines: moisture, oxygen, carbon dioxide, ammonia, cyanogen, hydrogen sulphide, sulphur dioxide, organic sulphur compounds, and electrolytic action; and on the outside of the pipes, moisture, contents of the clay, acid or alkaline condition of the soil, waste discharges from manufacturing plants, and electrolytic action.

Manufactured gas is stored in holders over water. It is therefore saturated with water vapor. Because the mains are under ground the temperature of the gas is therefore always under the dew point of water vapor. Therefore the inside of the pipe is always covered with a film

of moisture. Solutions of the various foreign substances of the gas are thus in immediate contact with the metal. Although these solutions are dilute, still they are the more highly ionized and are in the best condition for attacking the metal. Solutions of such electrolytes in the presence of two kinds of metals or of a metal and certain impurities or isolated alloy portions in the metal produce galvanic cells, thereby causing constant corrosion and pitting.

Complete analyses were made of rust samples taken from the mains. Samples of various gas line materials were placed for long periods in the plant mains between the wash box and the scrubber, between the scrubber and the purifiers, and between the purifiers and the big holder. Samples of different gas line materials were placed in jars on supports above solutions which saturated the closed space above with individual gases corresponding to the impurities and constituents of the gas. Short pieces of pipe of many alloy compositions were connected in the lines in the Chemical Engineering laboratory and the tendency of each to corrode was determined by actual measurements of the corrosion of the samples. The solution pressure of ferrous materials of many kinds and alloy composition were measured by the potential observed with a potentiometer and a calomel cell. The potentials of the metals measured in this way was found to be an accurate measure of the tendency of the metal to corrode in a given medium.

Many kinds of protective coatings were applied and subjected to the action of gas and its impurities in the lines over long periods. These studies with microphotograph show that gas tar applied hot by a pump from a spray nozzle attached to a very small pipe for spraying both the inside and the outside of the pipe is as satisfactory as any coating used. It also has the advantage of being a by-product of the gas plant.

CONCLUSIONS

1. The desirable constituents of coal and blue gas are not corrosive to gas mains and service pipes.

2. Careful control should be used in the making of gas to prevent as far as possible the making of impurities in the gas.

3. Gas should be carefully purified from cyanogen, ammonia, sulphur compounds, and as far as possible from other impurities. However, it has been found that commercial dehydration of gas is not feasible.

4. Wrought iron pipe is found to be very satisfactory for gas mains. Copper bearing and other special alloy steels have been found to be satisfactory.

5. Protective coatings increase the life of the pipe.

6. The potential method is a quick and efficient method for determining the most resistant metal to corrosive action in a given medium.

STATE COLLEGE,
RALEIGH, N. C.

MICROCHEMICAL STUDIES OF THE CHANGES DURING VERNAL ACTIVITY IN GINKGO BILOBA

By Ruth Scholz

Introduction

Although *Ginkgo biloba* is a deciduous tree, it belongs to the Gymnosperm group. The investigation of food storage in *Ginkgo biloba* was made to discover if the materials were similar to those stored in deciduous trees or if they were distinctive of the Gymnosperm group.

The chemical changes occurring during the morphological development of the buds of *Ginkgo biloba* were followed from primordia to the formation of the leaves and flowers. Chief attention has been given to the morphological origin of the resin ducts in the primordia of the bud, and also the analysis of the material which these ducts store. Microchemical tests made on the living tissue were, in most cases, checked macrochemically by water, alcohol, and ether extracts of the tissue. The work was carried on under the direction of E. H. Hall, Professor of Botany at the North Carolina College, with valuable suggestions and criticisms by Miss Florence Schaeffer of the Department of Chemistry of the same college.

Method

General and specific chemical tests were made in testing the substances in the plant cells for a microchemical analysis. These tests were based on color changes, precipitates, and solubilities resulting from chemical reactions. In some cases definite color changes could not be detected, although the correct chemical reaction occurred. Water, alcoholic, and ether extracts were made during various stages of development and the identical tests which were used microchemically on sections were made with these extracts. The results obtained by the two methods checked favorably. The material was brought into the laboratory two or three times a week and tested immediately. The buds were then kept in water in a warm, well lighted room and tested at intervals. Prepared slides were made of the closed bud so that the formation of resin ducts from primordial tissue might be studied. Sec-

tions were cut with a freezing microtome or free hand. Comparative tests were made at early morning and late night. The development of the buds was given careful attention from February 10th until April 30th.

RESULTS

Chemical changes of:

A. Carbohydrates

(1) Starch (reagent used—I_2KI) and Sugars (Fluckige test).

Feb. 9: In closed buds no starch or sugar was present.

March 9: Buds kept in water in warm, lighted room gave a test for starch in which the starch grains were large but present in small quantities. A reddish brown precipitate was obtained with Fluckige on heating, indicating the presence of glucose.

March 11: Buds pulled on 10th gave no starch test in early morning but a slight starch test at night.

March 12: Buds pulled on 10th gave no starch test in morning but a good starch test at night.

March 13: Buds pulled on 10th gave no starch test in morning but a good test at night.

March 16: Fresh sections gave no starch test when pulled in early morning but buds pulled in afternoon gave considerable amounts of starch.

March 22: Buds pulled on 16th gave no starch test in morning but a test at night.

March 24: Buds pulled in evening gave a starch test, the grains being small but numerous. In all cases recorded above where starch was obtained, glucose was found to be present in small quantities. The starch and sugar were not found in primordial tissue but only in outer layers of well differentiated tissue. In alcoholic and ether extracts of these buds no starch or sugars were found, but a positive test for glucose was obtained in the water extract.

April 12: Young leaves gave a starch test at night but no test in the morning. Also a slight test for glucose was detected at night.

April 13: Leaves gave a test for starch as early as 8:30 A.M. Starch occurred around ducts and bundles.

April 26: Leaves three-fourths grown gave neither starch nor sugar tests at night but both during the daytime.

(2) Hydrocellulose.

In the buds, callose was detected in the cells of the primordia. No lignin or methyl pentosans were present. In the stem, both methyl pentosans and lignin were found in pith and phloem. Callose was found in pith and pith rays; pectin in pith, pith ray, and phloem except bast.

B. Fats.

In the buds suberin was found in the cortical tissue of the bud scales, fat globules in resin ducts, myelin forms in resin ducts. In the leaves suberin was found in cell wall of epidermal cells, and fat globules and myelin forms in the ducts. (Reagent used-Sudan III and 10% ammonia for myelin formations.)

C. Proteins.

The bud sections stain yellow with picric acid, give xanthoproteic reaction in primordial tissue, stain red with eosin, give reactions with Biuret and Berlin blue in all tissue except primorida Alcoholic extracts give positive tests for protein with Biuret, Berlin blue, and xanthoproteic reactions. In the stem, protein was found in the pith, cambium, and phloem. In the leaves protein was found in the bundles and cells around the ducts.

D. Amino Acids.

In the buds the presence of small amounts of asparagin and glutamine was detected by quinone. No attempt was made to separate them. A large amount of tyrosine was found in the buds. The crystals were precipitated by alcohol, then dissolved in concentrated nitric acid, Millons', and sodium molybdate. These crystals were found in the bursting buds, but not in the young leaves. They again appeared in leaves one-half to three-fourths grown.

The material in the resin ducts of the buds was found to contain the following.

(1) Ethereal oils. These dissolved in glacial acetic and chloral hydrate, stained red with Sudan III, black with osmic acid, and gave mesnard test.

(1) Fatty oils. Stained with Sudan III but did not dissolve in glacial acetic or chloral hydrate; formed large drops with mesnard reagent but did not dissolve; disssolved in ammonia.

(3) Free benzoic acid. Formed silver benzoate with sodium acetate and silver nitrate.

(4) Resins. A green copper resinous compound formed on treatment with copper acetate.

The ducts in the bud scales do not give any of the above reactions. The ducts of the leaves give all of the above reactions.

DISCUSSION

From prepared slides the ducts may be seen to be present in the primordia of a closed bud. They are formed lysigenously by the disintegration of the cells and as definite secretions before the breaking down of the tissue. The ducts are found in the bud scales, mixed buds, and leaf buds, stems and leaves, but not in the megasporangium. The ducts contain ethereal oils, resins, fatty oils, and free benzoic acid. Their source may be as follows.

Fats are not stored at any other place in the bud or leaf except as suberin in cortical cells. The origin of the fatty oils may be traced as follows. The leaves in the summer make an abundance of starch. The starch is not stored but is converted into glucose. As the glucose is not stored it is, perhaps, converted into glyceraldehyde which in turn changes over to pyruvic acid, alanine, and other alpha amino acids. These amino acids are either changed to proteins or stored as tyrosine in large quantities and asparagin and glutamine in small quantities in the bud. The pyruvic acid may be converted into acetaldehyde which is the starting point in the building up of the fatty acid molecule. Since there is no fat found in the bud, and fatty oils are stored in ducts, it is to be concluded that the fat is stored in the ducts in the form of fatty oils. The ethereal oils are derivatives of the aromatic group of hydrocarbons and of the benzene ring which is present, since free benzoic acid was found. The resins contain the terpene grouping and are derivatives of the aldehydes.

Starch and sugars are not stored in *Ginkgo biloba*, but may be found only in leaves or buds due to photosynthetic action. They were found to be present during the day and at night, but were not present in the morning which indicates that they were converted into other substances during the night. No glucosides were present.

The only real storage product was tyrosine. This is the first amino acid to appear in decomposition of protein and is not, as a rule, the logical storage product. However Palladin says that in the absence of oxygen it accumulates to a marked degree while asparagin is negligible. In the presence of oxygen asparagin is the main product. The stored tyrosine is utilized in the leaf and flower formation, and fails to appear in young leaves. It reappears, however, when the leaves are one-half to three-fourths grown during active photosynthesis in smaller quanti-

ties than was first stored in buds. This reveals the fact that the starch and sugars are at once converted into tyrosine and other amino acids.

CONCLUSIONS

It may be concluded from this study that:

(1) Resin ducts are formed lysigenously in the primordia of the leaf buds.

(2) Fatty oils, ethereal oils, resins, and free benzoic acid are stored in these ducts.

(3) Starch is made photosynthetically as the first product and is not stored but converted into glucose and amino acids.

(4) The chief storage product of *Ginkgo biloba* is tyrosine.

NORTH CAROLINA COLLEGE FOR WOMEN,
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NOTES ON EXTENDED RANGES OF PLANTS IN NORTH CAROLINA

By W. C. Coker and H. R. Totten

We can report as new to the state of North Carolina a pretty little monocot, *Atamasco Treatiae,* which has not previously been reported north of Florida. A plant of this meadow lily was sent to us this spring by Mr. H. A. Rankin of Fayetteville, N. C. He collected it originally in Brunswick County, N. C., and grew the specimen sent us in his yard. In Florida it grows in pine woods according to Small (probably in wet pine woods). It differs from the common meadow lily in the much shorter peduncle (1–2 mm.), half terete, very narrow leaves with thick margins, and particularly in the style being shorter than the stamens instead of longer. In *A. atamasco* measured at the same time the styles were 1.5 cm. longer than the stamens and the peduncle varied from 6 mm. to 1.6 cm. long.

Asarum reflexum

On Third Creek about 6 miles each of Chapel Hill but in Durham County we found in bloom on the 17th of April fine beds of *Asarum reflexum* Bricknell, growing in rich swamp silt near the water. This is the first time this plant has been found in North Carolina except in the northwestern mountain section. It is a close relative of the Canada heartleaf and is considered a variety of it by Gray. These two belong in an entirely different section of *Asarum* from others of our region and are much more northern in their distribution. Aside from floral characters, this group differs most conspicuously from the other in being tomentose, with 2 thin, unspotted deciduous leaves a year, in the flowers being held well above the ground, and in the production of extensive beds by slender runners.

Hicoria laciniosa Sarg. Big Shell-bark or Big-leaf Shagbark Hickory.

This species, common in the low grounds of the central Mississippi basin, is found rarely in alluvial soil along streams in our lower moun-

tains. Prof. Earl H. Hall has reported the only collection out of the mountains in our state, finding it in Beaver Swamp in Guilford County.

Pinus Strobus. White Pine

This is a mountain plant rare even in Davie County, but there are a few large trees at the junction of Deep and Rocky Rivers at the southern edge of Chatham County (1921). One tree in 1921 measured 61 inches in circumference 3 feet above the ground; small trees and seedlings plentiful. People living near reported that about 35,000 ft. of white pine lumber were sawn about 1911 from this hill and the hill across the river in Lee County.

In this connection we might call attention to the previously reported occurrence in lower Wake County on a bluff facing Swift Creek of a grove of Canadian hemlock (this Journal **1**: 86. 1884, and Trees of North Carolina, p. 25, 1916).

Water Ash (Fraxinus caroliniana)

Usually found only in the deeper swamps of the lower half of the coastal plain, it was collected near Mitchell's Mill on Little River in eastern Wake County, Dec. 31, 1931 (Totten and Wells).

Buffalo Nut (Pyrularia pubera)

A mountain shrub, parasitic on the roots of other woody plants, found at Boone's Cave in Davidson County (Velma Matthews) and on the Yadkin River in Davidson County (spring 1932).

In indicating the range of distribution of plants, it is well to distinguish between what we might call the normal or natural range from the incidental or sporadic appearance of individuals outside of this range. For instance, the bay berry (*Myrica cerifera*) has not previously been found, so far as we know, in Orange or Durham Counties, but this spring one of our negro friends found a single well developed bush in a damp place about 3 miles north of Chapel Hill.

Another illustration is the groundsel tree (*Baccharis halimifolia*), a shrub of damp soil either salt or fresh in the coastal plain, commonest near the sea. A single plant of this was found in upland woods about ½ mile from Morgan Creek near Chapel Hill (1930), and another was seen in cut-over land near New Hope Valley road to Durham (July 1932).

Again in upland woods near the golf course has been found (1931) one plant of the narrow-leaved crab-apple (*Malus angustifolia*). We know of no other plant of it within 50 miles or more. All of these species are planted as ornamentals but we know of no plant of this crab-apple which has matured fruit in Chapel Hill in 30 years. In fact there is none in town now. The only ones that we know of during that time planted in Chapel Hill were young ones planted in the Arboretum. All of these were quickly killed by the cedar-apple rust. In fact this rust completely prevents the successful cultivation of any crab-apple in Chapel Hill. Bechtel's crab will struggle on here but is almost completely defoliated every spring by the rust. The gall-berry (*Ilex glabra*), one of the most common shrubs in damp places throughout the eastern counties, but not reported previously in Orange County, was found (a single plant) on a northward facing damp hillside less than one mile north of Chapel Hill (1932).

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MAYFLIES OF NORTH CAROLINA

PART III. THE HEPTAGENINAE

By JAY R. TRAVER

PLATE 15

In previous papers (Jour. Elisha Mitchell Sci. Soc. **47**: Nos. 1 and 2) I have recorded the species of mayflies of the subfamilies Ephemerinae and Baetinae, which I have taken in North Carolina. The remaining subfamily, Heptageninae, is treated in like manner here. In the keys presented at the beginning of this faunistic study (op. cit., p. 101), these three subfamilies were characterized. Further study has led me to believe that I was in error in following the traditional identification of some of the genera of this last subfamily. A more extended account of my present conception of this subfamily will appear in the near future, in the Journal of the N. Y. Ent. Society. I give here, therefore, merely a brief summary of that portion of the article which immediately concerns the North Carolina species, with a correction of my previous errors, and with revised keys to the North Carolina genera of this subfamily.

The word Heptagenia, as used in my previous paper (op. cit., p. 101), should be changed to Stenonema, and the word Ecdyonurus to Heptagenia. Examination of specimens of the type species of Ecdyonurus has convinced me that this word has been misapplied to those North American species which I now call Stenonema. I believe now that none of my North Carolina species belong to the genus Epeorus, but that all should be referred to Iron. I refer the reader to the more ex-

tended article in the JOURNAL, where I have set forth in detail my reasons for the above changes. The revised and corrected keys to the subfamily Heptageninae are as follows.

Key to the male imagoes

1. First joint of fore tarsus considerably shorter than second joint (never more than $\frac{2}{3}$ of second, often much shorter) 2
   First joint of fore tarsus equal to second joint, or slightly exceeding it in length . . . . *Iron*
2. First joint of fore tarsus very short ($\frac{1}{6}$ to $\frac{1}{4}$ of second) 3
   First joint of fore tarsus longer ($\frac{1}{3}$ to $\frac{2}{3}$ of second) . . . . *Stenonema*
3. Lobes of penes separated from one another very near the base, thus appearing as two long narrow projections. Cross veins in stigmatic region tend to anastomose . . . . *Rhithrogena*
   Lobes of penes joined together except near apex; broad, often somewhat angular laterally and distally; never as above. Cross veins of stigmatic region not anastomosed . . . . *Heptagenia*

Key to the nymphs

1. Tails two, in mature nymph . . . . *Iron*
   Tails three, in mature nymph 2
2. Gills of seventh pair tapered threads or spines; tracheae, if present in these, without lateral branches . . . . *Stenonema*
   Gills of seventh pair flat and plate-like; tracheae always present in these, and with lateral branches 3
3. Gills of first and last pairs much enlarged, converging beneath the body *Rhithrogena*
   Gills of first and last pairs not as large as some of central pairs; directed laterally, not converging beneath body 4
4. Postero-lateral margins of pronotum prolonged backwards into epaulet-like extensions . . . . *Ecdyonurus*
   Postero-lateral margins of pronotum not prolonged backwards . . . . . *Heptagenia*

Genus HEPTAGENIA Walsh 1863

Although twenty-seven species of this genus have been described from North America, only six species appear in my collections from North Carolina. Two of these are new. It should be noted here that those species previously described or listed from North Carolina by Eaton and Banks, as Heptagenia, now fall into the genus Stenonema.

No representatives of this genus were found in the coastal plain region. The following keys may be useful in distinguishing the nymphs and imagoes of these species.

Key to male imagoes—Heptagenia—North Carolina species

1. Genitalia of the *maculipennis* type (see Fig. 15). Basal costal cross veins, sometimes other cross veins, margined with brown or black................2
   Genitalia not of the *maculipennis* type. Basal costal cross veins not dark-margined..3
2. All veins in posterior half of forewing colorless. Abdominal tergites unmarked except dark posterior margins..........................*juno*
   Cross veins in posterior half of forewing brown. Abdominal tergites marked laterally with broad brown patches........................*aphrodite*
3. Veins colorless. Size under 6 mm.................................*spinosa*
   Veins brown. Size 7 mm. or over.......................................4
4. Genitalia of the *flavescens* type (see Fig. 8). Abdomen with black oblique lateral stripes, no dark median dorsal band...................*marginalis*
   Genitalia of the *elegantula* type (see Fig. 1). Abdomen with broad dark median dorsal band, no black lateral stripes.............................*julia*

Key to nymphs—Heptagenia—North Carolina species

1. Filaments present on gills of seventh pair. Pronotum widest at anterior margin..2
   Filaments absent from gills of seventh pair. Pronotum widest at middle...3
2. Abdomen with oblique black lines on each side of tergites. Very short lateral spines on segments 6 and 7.................................*marginalis*
   Abdomen without oblique black lateral lines. No lateral spines on segments 6 and 7...*julia*
3. Three small light spots on each side of frontal margin of head. Tergite 8 and anterior half of 9, largely white.................................*aphrodite*
   No light spots on frontal margin of head. Tergites 8 and 9 without such a prominent white blotch...4
4. Sternites 8 and 9 with dark transverse bars..........................*juno*
   Sternites 8 and 9 without dark transverse bars........................sp?

From the piedmont region

Heptagenia marginalis Bks.

This was the most common species of Heptagenia in the piedmont, although not abundant at any place. Mature nymphs were collected and reared from several stations, so that the identity of the species and the correct association between nymph and imago was established. Collections were as follows. Near Denton, May 14, 1929; Caraway Creek near Sophia, May 11–17, and Sept. 29, 1929, and May 20, 1930; Big Alamance Creek, Sept. 30 to Oct. 14, 1929; and Little Alamance Creek, Sept. 8, 1929.

Heptagenia aphrodite McD.

Nymphs of this species were taken from two stations and nymphs reared from them. On Oct. 1, 1929, a female was reared from Big Alamance Creek. Nymphs were likewise reared from Caraway Creek near Sophia on May 1, 1929; Sept. 28, 1929; and May 11–24, 1930. I present the following description of the nymph.

Nymph

Size—Body 6–6½ mm.; tails broken, in all specimens.

General color—Dorsally, brown with cream-white markings. Ventrally, creamy white to light tan.

Head—Many small round brown spots (or papillae?) along frontal border. Light-colored bar from outer anterior margin of eye to lateral border. Small white spot anterior to each ocellus. On margin of frons, three small white spots on each side, the posterior ones larger. Three white spots on each side of vertex near inner margin of eye. Base of antenna light brown, greyish white distally. Mouthparts very similar to Eaton's figure of a nameless North American nymph (Monograph, Pl. 59). The labrum, however, is slightly emarginate in front, and its lateral extensions do not turn downward so sharply. Right mandible with 4 long slender hairs on upper margin at base of inner canine; 3 such hairs on left mandible. 15 to 16 pectinate spines on crown of maxilla.

Thorax—Pronotum widest at middle. Lateral margins colorless. White mark like an inverted L, its base on anterior margin, on each side. Between this and the colorless margin, a brown bar followed by a light one. Curving white mark along center of posterior margin. Many small irregular white marks on mesonotum, including an L-shaped mark between the wing roots, and a round spot anterior to each wing root.

Legs—Femur white at base and tip, with white extensions into main brown portion from basal area. Two round white spots on hind margin, two smaller ones on forward margin, and two in central area. Hind margin fringed with long tawny hairs. Many small brown to orange spines on upper surface. Femoral flange short (not extending out beyond remainder of femur). Tibia light brown, with wide median and apical white bands. Hind margin fringed with hairs. Tarsus light brown basally, white apically. Claw with usual median spine on inner margin, less well developed than in *marginalis*. In addition, three slender teeth or spines near tip (i.e., claw is pectinate).

Abdomen—Lateral margins of 3–7 extended. Postero-lateral spines present on 3–8; very short on 3, increasing in length to 6; 7 somewhat shorter than 6; 8 shorter than 7 but longer than 3. Dorsally, segment 1 largely white, with narrow brown transverse band near posterior margin, and brown laterally. Segments 2, 3, 8, and 10 largely brown. White submedian marks on 2, 3, and 6, and other white marks near posterior margin and nearer the lateral border. Anterior half of lateral border white. Segment 10 is narrowly lighter on anterior margin and on each side of dark median line. Segments 4, 5, and 7 have large white central areas bordered on all sides by irregular brown blotches. Lateral margins as in 2–3; irregular brown longitudinal band parallel to lateral margin. Segment 8 and anterior half of 9 dark brown. Ventrally, immature nymphs are creamy white, mature ones light tan, with faint traces of darker longitudinal bars on each side.

Gills—Seventh gill lacks lower filamentous portion. Filaments of lower portion of other gills not as well developed as in *marginalis*. Plate-like parts greyish to light purple; tracheae and filaments purple.

Tails—Light tan at base, becoming somewhat lighter distally. Joinings dark brown, alternate joinings wider.

Heptagenia juno McD.

This species was found in one locality only. Nymphs collected on May 3, 1930, at the Cascades, near Danbury, in the Sauratown Mts., transformed from May 4 to May 19. Several specimens of both sexes were reared. The description of the nymph follows. In general structural characters it agrees with *aphrodite*, both species belonging to the *maculipennis* group.

Nymph

Size—Body of female, 6½ to 7 mm.; tails 11 mm.

General color—Light reddish brown dorsally, creamy white to pale yellowish ventrally.

Head—Small white dots along frontal margin, less prominent than in *aphrodite*. Small white spot anterior to each ocellus. Narrow white bar from outer anterior margin of each eye to lateral margin of head. Small light spot on each side of vertex, about at middle. Antenna reddish brown. Mouthparts very similar to *aphrodite*. 8 slender hairs at base of inner canine on right mandible, 7 on left mandible. About 20 pectinate spines on crown of maxilla.

Thorax—Pronotum widest at middle. Narrow colorless area on lat-

eral margins. Median line narrowly white. Rounded white blotch on each lateral anterior margin. Smaller hour-glass-shaped white mark near middle on each side. Mesonotum with several irregular white marks; a horse-shoe-shaped mark near wing roots; between wing roots a wedge-shaped mark, its base directed posteriorly, enclosing a small dark spot. White blotch at wing roots.

Legs—Femur narrowly whitish at base and apex. One round and one oblong white mark near, but not on, hind border. One to three small rounded marks in central area. One to three small light marks along fore border. Hind border fringed with long hairs. Spines on upper surface longer than in *aphrodite*. Tibia and tarsus reddish brown, no white marks. Tibia fringed with hairs on hind margin. Claw very similar to that of *aphrodite*. Femoral flange projects beyond main body of femur.

Abdomen—Postero-lateral spines as in *aphrodite*. Dorsally, segments 9 and 10 entirely brown. Segments 3 and 6 almost entirely brown, with small light marks only in lateral margins, and a white triangle on each side near the posterior margin halfway between median line and lateral border. Segment 1 largely white. Segments 2, 4, and 5 with white marks as on 3 and 6, and in addition two larger submedian marks, confluent apically, arising from posterior margin. Segments 7 and 8 quite similar to 4 and 5, but white submedian marks are shorter and broader. Ventrally pale yellow on apical segments, whitish on proximal ones. Segment 9 with dark brown lateral margin and transverse brown bar on anterior margin, usually discontinuous on median line. Two dark brown submedian spots on anterior margin of sternite 8, connected by a brown bar. Traces of similar marks on 7 are sometimes present. Extreme edge of lateral margins of all segments dark brown.

Gills—Structurally as in *aphrodite*. An area posterior to center of each plate-like portion purple, the margins light grey. Tracheae not distinct. Filaments light grey.

Tails—Amber yellow to light tan. Joinings reddish brown, alternately wide and narrow.

From the mountain region

Heptagenia marginalis Bks.

While not as common as *H. julia* n. sp., *marginalis* was quite well represented throughout the mountainous portion of the state. Collections from this area are listed. Davidson River, June 18, 1929; Ocona

Lufty River, June 22, 1930; Cullasaja River near Franklin, July 3, 1929; South Toe River at Micaville, July 6, 1930; Bald Creek near Burnsville, July 6, 1930; Spring Creek near Hot Springs, July 11, 1930; Little River near Penrose, July 12, 1930; and Toxaway River near the falls, July 16, 1930.

Specimens were reared in May, and again in September and October, from the piedmont. In the mountains, July was the time of emergence.

Since the nymph of this species does not seem to have been described, I give a description of it, as well as a figure of the male genitalia (Fig. 8). The species would seem to be rather close to *flavescens* Wlsh., the genotype, if similarity in structure of genitalia is any criterion, as I believe it to be. Since the nymph of the genotype is not known, it is not possible to compare this species with it, but I do not doubt that the two will be found quite similar in structural details.

Nymph

Size—Body of male, 9½–10 mm.; female, 11 mm. Tails of female, 22 mm.

General color—Light brown dorsally, creamy white ventrally.

Head—White spots laterad of each lateral ocellus and between the ocelli. Smaller white spot anterior to median ocellus. Small white spot anterior to each compound eye, another at inner margin. Epicranial suture white. Small light spot at middle of vertex. Antenna brown. Mouthparts very similar to figures by Eaton (Monograph, Pl. 61) for a species listed as Ecdyonurus.

Thorax—Pronotum widest at anterior margin. White spots (1) at middle of lateral margin; (2) at center of anterior margin; (3) irregularly along posterior margin; and (4) large area at middle of segment on each side of median line. Black longitudinal lines and scroll-like markings enclose the central white area. Oval white spot at middle of mesonotum on each side of median line, and another anterior to wing roots. Wing-cases brown, whitish at roots.

Legs—Femur brown, with three zigzag transverse bands, at middle and near each end. Femoral flange prominent, rounded apically. Upper surface of femur thickly set with short spines. Hind margin fringed with relatively long hairs. Tibia brown with distal and median white bands. (One specimen, entire distal half white.) Hairs on hind margin. Tarsus brown, lighter distally. Claw white, its tip orange. Usual median spine on inner margin, but no teeth at tip (i.e., not pectinate).

Abdomen—Dorsally, each segment narrowly black on posterior margin. Segment 1 largely white. Segments 2–8 with a longitudinal black stripe midway between median line and lateral margin, on each side. On 2–7, white submedian dash on each side near middle of segment. Lateral margins white, except for brown postero-lateral angles. Round white spot between lateral margin and longitudinal black stripe (very small on 5). Large irregular creamy white blotch on middle area of segment 8. Smaller light spot at middle of 9, on each side of brown median bar. White streak on each side of brown median line on 10. Lateral margins of 1–7 expanded, with very short postero-lateral spines. Ventrally creamy white, tinged with yellow on apical segments.

Gills—Filamentous lower portion present on all gills, well developed. Upper plate-like portion light grey with purple tracheae. Filaments purple.

Tails—Brown. Alternate segments with creamy white joinings. Except near base, a white blotch covering one or two segments alternates with three or four brown segments. Pale amber at extreme tip.

Heptagenia aphrodite McD.

A male and several females were taken in flight as subimagoes over Flat Creek, at Black Mountain, on June 30, 1930. These transformed to imagoes. Nymphs taken from this stream were similar to those reared from the piedmont. A somewhat darker male, taken in flight near Waynesville, is tentatively referred to this species, but may belong with the female listed as *Heptagenia* sp. Nymphs were found likewise at Laurel River not far from Hot Springs on June 29, 1930.

Heptagenia sp.? (*maculipennis* group)

A female nymph, taken in a tributary of the Pigeon River four miles west of Hazelwood, transformed on July 24, 1929. Although this species is a member of the *maculipennis* group, the nymph differs from *juno* and also from *aphrodite*. Another nymph of this species was taken in Hominy Creek near Canton on July 18, 1930.

Female imago

Size—Body 7½ mm.; wing 8½ mm.

Head—Margin of clypeus dark.

Thorax—Pronotum marked with greyish brown. Remainder of thorax yellowish, with a few lateral brown marks.

Legs—Pale. Fore femur with median brown band and brown at distal end. Black streak on distal third, on inner margin.

Wings—Three basal costal cross veins, two at bulla, and three subcostals at bulla, brown-margined. Other veins dark brown.

Abdomen—Largely orange brown, paler ventrally. Each tergite has an irregularly rhomboidal dark lateral patch, rather as in *aphrodite*, but more extensive. Tergites 2 and 3 dark. 4–6 have large light median patches, and short submedian dark marks. Tails white, unmarked.

Nymph

Head and *thorax* very similar to *juno*.

Legs—Femur pale, with three dark transverse bands. Fringed on hind margin with long hairs. Short spines on upper surface. Tibia light brown, tarsus darker brown, both unmarked. Three pectinations on claw.

Abdomen—Tergites 2, 3, 6, and 9 largely brown, the two latter very dark. Tergite 1 largely pale. Remaining tergites brown basally, whitish in apical half. Apical margin of brown area irregularly scalloped. Ventral surface unmarked except for narrow brown lateral border on sternite 9. Gills much as in *juno*. Tails yellow, joinings dark brown.

? Male imago

It is possible that the dark male taken at Waynesville on July 17, and tentatively listed as *aphrodite*, may really belong to this species. Genitalia of this male are very similar to *aphrodite* (see Fig. 15).

Somewhat similar nymphs were taken from the Ocona Lufty River on June 2, 1930, and from the Rocky Broad River at Lecky Gap on June 23, 1930. None were reared. These may represent still another species of the *maculipennis* group.

Heptagenia julia, sp. nov.

This species is close to *pulla* Clem., but smaller. I had at first considered it to be *pulla*, but think now that it is a distinct species. Thorax reddish brown dorsally. Abdomen pale yellowish, semi-hyaline, the tergites purplish along median line. Segments 8–10 deeper yellow, opaque.

Male imago

Size—Body 7–8½ mm.; wing 7½–8½ mm.; tails 12–19 mm.

Head—Pale yellowish, tinged with reddish brown on vertex. Narrow

black transverse line on each side of front, extending out from compound eye. Antenna pale yellowish brown. Bases of ocelli black.

Thorax—Pronotum light reddish brown, with lateral purplish brown area. Posterior margin narrowly black at center. Meso- and meta-nota darker reddish brown, the tips of the spines very dark. Pleura yellowish. Conspicuous round black spot above fore coxa. Black line on mesonotum anterior to and below wing roots. Black lines anterior to middle and hind coxae; purplish line posterior to each. Pale yellow ventrally, except posterior half of mesosternum, which is yellowish brown.

Legs—First fore tarsal joint about ½ of second. Fore leg dusky. Fore femur with indistinct purplish median band. Distal end purplish brown. Remainder of leg tinged with same color. Black streak on inner margin of distal fourth of fore femur. Tibio-tarsal joining and joinings of tarsus narrowly darker. Black streak on inner margin of first tarsal joint. Femora of other legs pale yellowish with indistinct dusky tinge; narrowly darker at distal end. Tibiae and tarsi dusky.

Wings—Semi-hyaline. Stigmatic area opaque. All veins light brown, the three large veins of the costal margin somewhat yellowish

Abdomen—Segments 1–7 pale yellowish, semi-hyaline. Segments 8–10 yellowish red, paler ventrally; opaque. Posterior margins of all tergites narrowly purplish black. Tergites 1–4 with wide median purplish band, becoming wider posteriorly on each tergite. Median purplish band on tergites 5–7 also, but somewhat narrower. Whitish submedian blotches within this purple band, on each tergite. In tergites 1 and 2, these are based on anterior margin, but are nearer the center on tergites 3–7. Minute black line at stigma in each segment. Unmarked ventrally.

Tails—Dusky at base, becoming pale yellowish brown distally. Joinings dull purplish, except three or four at base which are pale. These purple bands alternately wide and narrow in basal third.

Genitalia—Of the *elegantula* type. Very close to *pulla* Clem., but distinguished by smaller size and slight structural differences. Forceps and penes dusky, subanal plate yellowish. See Fig. 11. The apical projections of the penes are more acute than in *pulla*, and the two central pairs of spines differ as follows. In *pulla*, the lower pair is very long and stout, the upper pair shorter and somewhat curved. In *julia*, both pairs of spines are nearly alike in size and shape. The second joint of the forceps of *pulla* is likewise longer relatively than in *julia*. I figure also the genitalia of *pulla* (Fig. 1). This is a camera lucida sketch from

a slide which Dr. McDunnough kindly lent me for comparison with *julia*.

Female imago

Very similar to male imago. Somewhat paler. Abdomen opaque, flushed with pink before eggs are deposited. Body 7–8½ mm.; wing 8–10 mm.; tails 13–16 mm.

Nymph

Size—Body of female, 8–9 mm.; tails 15–17 mm.

General color—Dark reddish brown dorsally, creamy white to pale yellow ventrally.

Head—Large white spot anterior to each ocellus. Small white spot on each side of vertex, posterior to each lateral ocellus. Another white spot on median line at center of vertex. Epicranial suture white. Narrow white line from outer anterior margin of eye to lateral border of head. Basal sclerite of antenna white. Filament pale brown basally, whitish distally. Mouthparts very similar to *marginalis* Bks.

Thorax—Pronotum widest at anterior margin. Somewhat crescent-shaped white area at center of anterior margin of pronotum. White spot in each anterior lateral angle. Irregular L- shaped white mark at middle of each side. Lateral margins narrowly colorless. Mesonotum with white streak on median line, widest at anterior margin. Small white spot anterior to each wing root. Slender elongate or oblong white mark on each side between wing roots, near median line. Laterad of this, another small oval white spot.

Legs—Femur narrowly light at base. Three rather irregular light bands, at middle and near each end, often not extending the width of the femur. Narrow white border, wider at each end, along basal half of hind margin. Two brown blotches on lower surface, at hind margin. Femoral flange projects beyond body of femur; rounded apically. Femur fringed with rather long hairs on hind margin. Upper surface with short brown spines. White band on tibia just before the middle, another at distal end. Hind margin fringed. Tip of tarsus white. Claw orange at tip, elsewhere white. Not pectinate.

Abdomen—Lateral margins of 1–7 slightly produced, but lacking definite spines. Each tergite with purplish black posterior margin. Rather broad dark band on median line of tergites 1–7, and basal half of 8. White submedian marks on each tergite, also a small white spot at middle on each side, halfway to lateral margin. Large white blotch

at center of lateral margin. In some specimens the submedian marks on 4 and 8 (not 4–8) are connected posteriorly, thus resembling *pulla* Clem. In many other specimens this is not the case. Tergite 10 has only the submedian light marks. Ventrally creamy white to pale yellow, the apical segments more often tinged with yellow. Sternites 8 and 9 with dark brown lateral border, forming a wide bar on 9. Traces, more or less distinct, of a dark longitudinal line parallel to lateral margin, on each side of body.

Gills—Seventh pair with filaments. Gill plates grey, tracheae and filaments purple.

Tails—Light brown at base, becoming darker distally. Joinings darker. Except at base and tip, each alternate two (or three) segments are dark, the next two lighter. Tip lighter brown, no such alternating dark and light patches.

Holotype—Male imago, reared. North Fork of Swannanoa River near Black Mountain, N. C., July 3, 1930. No. 1114.1 in Cornell University collection.

Allotype—Female imago, reared. Tributary of Pigeon River four miles west of Hazelwood, N. C., July 21, 1930. No. 1114.2 in Cornell collection.

Paratypes—8 male imagoes, 17 female imagoes. Waynesville, N. C., July 20–26, 1929; Allen's Creek near Hazelwood, July 18 and 24, 1929; Flat Creek at Black Mountain, July 2, 1930; Rocky Broad River at Lecky Gap, July 2 and 6, 1930; tributary of Pigeon River west of Hazelwood, July 27 and Aug. 2, 1930; tributary of Davidson River in Pisgah Forest, July 17, 1930; and tributary of the French Broad River at Selica, July 15, 1930. No. 1114.3–27.

This species differs from *pulla* Clem. (1) in its smaller size; (2) in structural details of penes as already noted; (3) darker color of legs and tails of imagoes; (4) the presence of a black line in the stigma of each tergite; and (5), the slight color differences in the pattern of the nymph. (One specimen was noted in which legs and tails were as light in color as in *pulla*.) Its habitat likewise is different. Clemens writes of *pulla* (Canad. Ent. **45**: 33), "the nymphs were found along the very stony, exposed shores of small islands three and four miles out in the open bay" (Georgian Bay). Nymphs of *julia*, on the contary, were the commonest species of Heptagenia in the mountains of the state, found in practically all the streams, both large and small, of that area. The

wide distribution of the species in the state is indicated by the following localities (other than those listed for the types): Swannanoa River at Black Mountain; Catawba River near Andrews Geyser; small stream near Fairview; tributary of the Rocky Broad at Bottomless Pools; Davidson River and one of its tributaries; tributary of the Cullasaja River near Franklin; tributary of the Tuckaseegee River on Cowee Mountain; tributary of Laurel River near Hot Springs; tributary of the Nantahala River near Topton; Wayah Creek near Franklin; Bald Creek near Burnsville; tributary of the North Fork of the Catawba River near Woodlawn; Conestee Creek; Little River near Penrose; Little River at Cedar Mountain; tributary of Allen's creek at Hazelwood; Scott's Creek; and Cedar Creek near Glenville. Collections were made at the above-mentioned stations during June and July of the summers of 1929 and 1930.

Heptagenia spinosa, sp. nov.

A small species, represented by three male imagoes only. The genitalia differ from those of all known North American species, in bearing lateral spines on the penes. Hence the specific name. Thorax reddish brown dorsally. Abdomen whitish, semi-hyaline, last three segments opaque, yellow. Broad purplish dorsal stripe.

Male imago

Size—Body 5–5½ mm.; wing 5½–6 mm.; tails 11 mm.

Head—Pale yellow without distinct marks. Bases of antennae white; filament dusky. Ocelli black-ringed at base.

Thorax—Pale reddish brown dorsally. Pleura and sternum creamy white to pale yellow; without markings. Pronotum purplish brown on median line and at center of posterior margin. Metanotum darker than remainder of thorax. Purplish on posterior margin, and at center a transverse purplish line.

Legs—Pale whitish with faint yellowish tinge. Fore leg more yellowish than others. Fore femur light purple at femoro-tibial joining, and with faint dark stripe on distal inner margin. Other legs with faint darker ring at distal end of femur. First fore tarsal joint between ¼ and ⅓ of second.

Wings—Hyaline. All veins colorless.

Abdomen—Segments 1–7 whitish, semi-hyaline. Segments 8–10 yellow dorsally, creamy white ventrally; opaque. Broad purplish dorsal band on 1–8, leaving lateral margins widely white. Whitish

submedian streaks within this dark band, and mid-dorsal line narrowly white. Posterior margin of each tergite narrowly dark purple, along extent of dark median band. On tergites 1–5, the purple band is lighter posteriorly, and darker from this light area forward to center of tergite.

Tails—White, tinged with yellow at base. Joinings narrowly purplish in basal third; remaining portion unmarked.

Genitalia—Forceps faintly smoky; penes pale yellow. Penes of a different type from any other species of this genus in North America. Forceps long and slender, the two terminal points together as long as the second joint (as in the *lucidipennis* group). Penes united, bearing a pair of stout blunt spines on the median line, and several short spines on each lower lateral margin. (See Figs. 6 and 7.)

Holotype—Male imago. North Fork Swannanoa River, N. C., June 30, 1930. No. 1115.1 in Cornell University collection.

Paratypes—Two male imagoes, same data. No. 1115.3–4 in Cornell collection.

These three males were taken as subimagoes, at the lights of the automobile, about 9.30 p.m. the evening of June 30, on the banks of the North Fork of the Swannanoa River. They transformed into imagoes the following day. Females and nymphs of this species not known.

Genus ECDYONURUS Eaton 1868

I have recently had the opportunity to study nymphs and imagoes of the genotype of Ecdyonurus, *E. venosus* Fab. These specimens were kindly sent to Prof. Needham by Prof. M. E. Mosely of S. Kensington, England. It would seem from these specimens that Ecdyonurus is a valid genus, distinct from true Heptagenia on the one hand and from Stenonema on the other, and one which has not been reported from North America. (Species listed as Ecdyonurus by Dr. McDunnough and others, now fall in the genus Stenonema.)

Nymphs of Ecdyonurus, as described and figured by Eaton (Monograph, Pl. 62, Figs. 1–23) possess an epaulet-like postero-lateral extension of the pronotum. Schoenemund (Zool. Anz. **90**: 45. 1930) uses this character as the basis for separating nymphs of Heptagenia from those of Ecdyonurus. North American nymphs of the genus Stenomena are probably not known to him. In his account of the

mayflies of Germany (Die Tierwelt Deutschlands, 19 Teil, 1930) moreover, Schoenemund includes in the genus Heptagenia the species *gallica*, *coerulans*, and *flava*, nymphs of which (op. cit. 78, figs. 129 and 132) are quite different from any known North American species of Heptagenia. Regarding gill structures, spines on the abdominal segments, and pectination of claws, the specimens of *E. venosus* differ very little from the North American Heptagenia nymphs of the *maculipennis* group. The hypopharynx of *E. venosus* is not quite similar to that of any North American Heptagenine I have studied, but otherwise the mouthparts resemble Heptagenia.

Among my North Carolina specimens are a few nymphs which resemble those of *E. venosus* in the peculiar posterior extension of the pronotum. In all other characters they are so similar to Heptagenia nymphs of the *maculipennis* group as to lead me to think that they belong to that genus rather than to Ecdyonurus. Since, however, none of these nor similar nymphs were reared, the genus cannot be definitely determined. I place them tentatively in the genus Ecdyonurus, because of the structure of the pronotum.

These nynphs were taken from the Toxaway River just above the big falls, on July 16, 1930, and from the Pacolet River at Tryon, July 14, 1930. Nymphs which show a very slight development of the hind angles of the pronotum occurred in the Rocky Broad River at Lecky Gap and in the tributary of the Pigeon River west of Hazelwood in June and July. The following description is based on the specimens from the Pacolet River.

? **Ecdyonurus** sp?

Size—Body 7 mm.; tails broken (on Toxaway River specimen, 10 mm.)

General color—Light reddish brown dorsally, pale ventrally.

Head—Very small white spot anterior to median ocellus and laterad of each lateral ocellus. Narrow white line from outer edge of eye to margin of head. Frontal portion of head very large. A few indistinct brown dots on frons, as in Heptagenia nymphs of the *maculipennis* group. Mouthparts very similar to *H. aphrodite* and *juno*, the outer margin of the mandibles rather more strongly incurved. Five long hairs at base of inner canine, on each mandible.

Thorax—Pronotum widest at middle, its postero-lateral margins extended backwards in a short, rounded projection. Irregular white

marks on anterior margin, near middle of each side. Mesonotum marked irregularly with creamy white. Pale whitish ventrally.

Legs—Coxae and ante-coxal pieces marked with dark brown. Femur brown, its basal and apical ends white. White median transverse bar, another near distal end. Small white spot in central area, between base and median bar. Hind margin fringed with long hairs. Upper surface with many small dark spines. Large brown spot on ventral surface at distal end. Femoral flange prominent. Tibia pale dusky brown in basal two-thirds, pale distally. Hind margin white. Cap-like basal portion adjoining femur, and fore margin, narrowly black. Tarsus and claw brown, unmarked. Claw pectinate.

Abdomen—Postero-lateral spines on segments 3–8, long except on 3. Tergite 1 largely whitish. Tergites 2, 3, 9, and 10 largely brown; 2 and 3 with black marks. Tergites 4–8 creamy white posteriorly, dark brown basally. Three roughly triangular brown areas, with black markings, on anterior margin, projecting backwards into light area; their edges irregular. Tergite 6 wholly brown at center. Tergites 5, 7, and 8 with wide white blotches on each side of narrow dark median line. Ventrally pale creamy white, apical sternites yellow-tinged. Sternites 8 and 9 with brown lateral margins, wider on 9.

Gills—Filaments absent from seventh gill. Gill plate mainly dark purplish grey, light grey on basal portion of outer margin. Only main trachea distinct. Filaments light purplish grey.

Tails—Dusky brown. Basal third of each segment white, distal portion brown. Joinings dark brown, alternately wide and narrow. Circle of spines at each joining, as in Heptagenia. Distally, dark joinings less prominent.

Genus IRON Eaton 1883

Mature nymphs of the Epeorus—Iron group are two-tailed, a character which distinguishes them from all other eastern Heptageninae. I am considering all known species of this group from eastern North America, with the exception of *Epeorus albertae* McD., as belonging to the genus Iron. For a further discussion of this question, I refer the reader to my paper on the subfamily Heptageninae (Journ. N. Y. Ent. Soc.).

Several species of Iron were taken in North Carolina. These may be divided, on structural characters, into two groups. Group I has the following characters. (1) Gills of first pair shorter than others, and broader at base, produced into a short lobe on the anterior margin.

These gills do not approach one another closely beneath the body of the nymph. (2) Head not noticeably wider at front margin than elsewhere, usually widest at or near middle. (3) Outer postero-lateral spines of abdominal segments long and sharp-pointed. Those of the central segments usually as long as or longer than one-half the length of their respective segments, and about three times as long as their own width at base. Inner spines usually about one-half as long as outer ones. (4) Femoral flange of the last two pairs of legs sharp-pointed at apex. (5) Five short teeth or spines near tip of each claw, on inner margin.

Group II is characterized thus. (1) Gills similar to those of Group I. (2) Head definitely widest anterior to middle, usually near the front margin. Hind margin relatively very narrow. Eyes small for size of head. (3) Outer postero-lateral spines usually short and rather blunt. Those of central segments not longer than one-fourth of the length of their respective segments, and about as long as their own width at base. Inner spines about as long as outer ones. (4) Femoral flange of second and third pairs of legs rather short and blunt at apex. (5) Four short teeth or spines on inner margin of each claw, near the tip.

While Group I has the nymphal characters usually assigned to the genus Epeorus, the male imagoes of the one reared species of this group have dissimilar fore claws. (In Epeorus the fore claws of the male are similar and blunt.) Group II, however, does not have the characters usually assigned to Iron, as the gills of the first and last pairs are not greatly enlarged, and do not meet beneath the body of the nymph. The genitalia of the male imagoes are very similar to those of Group I, and the fore claws of the males are dissimilar. Group II is thus intermediate between Epeorus and Iron, as these genera were characterized by Eaton. As stated before, I consider all these forms as members of the genus Iron.

At least four species of Group I and two species of Group II were collected in the state. Of these, complete life histories were obtained for two, both of which proved to be new species. Female imagoes alone were reared from nymphs of a third species. The two new species are described. The unreared nymphs, and the species with incomplete life history, are indictated by number only. The latter may also be new. Very little attempt is made to describe the unreared nymphs, as they are very similar one to another. Aside from the one species listed as No. 1, which was taken at two different places in the piedmont, all were found in the mountain area of the state.

Iron rubidus, sp. nov.

A species of Group I. Very close to *humeralis* Morgan. Gills of nymph distinctly reddish. Wings semi-hyaline, longitudinal veins very faintly brownish. Male whitish. Abdominal tergites with narrow dark posterior borders, black medio-dorsal line, indistinct dark lateral streaks and faint dark stigmatic marks.

	SIZE		
	BODY	WING	TAILS
Male imago	8 – 9	8–9	25
Female imago	9½–11	11	17

Male imago

Head—Pale yellowish. Small brown spot on each side of median carina, between antennae. Brown streak on each side of face, at corner of eye. Posterior margin of vertex brown at center. Base of antennae pale; filament faintly dusky, tip pale. Eyes of living insect bright green.

Thorax—Pale yellowish brown. Lateral and posterior margins of pronotum brown; brown streak on each side of median line, from middle to posterior margin. Mesonotum with four small dark marks between wings. Scutellum orange-brown, posterior margin black, with white lateral areas. Metanotum whitish anteriorly; posterior half orange-brown, purplish laterally. Pleura pale. Several purplish black marks on coxae and above each leg. Ventrally pale yellowish.

Legs—First joint of fore tarsus very slightly shorter than second joint. Legs pale yellowish. Each femur yellow, with usual prominent dark median band, and narrowly dark at apex. Fore femur slightly dusky. Tip of fore tibia purplish. Claws of all legs dissimilar.

Wings—White, semi-hyaline. Longitudinal veins very faintly yellowish brown. Humeral cross vein black in half next to subcosta. Stigmatic area opaque white.

Abdomen—Segments 1–7 white, semi-hyaline. 8–10 yellowish brown, paler ventrally; opaque. Each tergite with narrow purplish black posterior margin, faint at center. Medio-dorsal line purplish black in posterior half of tergites 3–9. On 1 and 2, a black median dot only. Purplish mark in stigmatic area of each tergite, and traces of dark

lateral marks on each side. Sternite 1 opaque, pale yellowish. Venter pale, unmarked.

Tails—White, unmarked.

Genitalia—White. Very similar to *humeralis* Morgan, but short lateral projections on penes less prominent. Second joint of forceps slightly longer, relatively, than in *humeralis*. See Fig. 9.

Female imago

Very similar to male. Abdomen rose to salmon-red, due to color of eggs. Lateral and stigmatic marks very faint, also posterior margins less well-marked than in male. Cross veins of stigmatic area of fore wing light brown. In living insect, eyes are bright green. Fore part of head and pronotum deep orange. Pleura marked with orange.

Nymph

Very similar to that of *humeralis*, but differs from it in (1) the reddish color of the gills; (2) whole body definitely reddish to yellowish brown (in *humeralis*, greenish brown); (3) legs barred with reddish brown (in *humeralis*, with greyish brown); and (4) branches of tracheae in gills much less numerous, also less prominent, being dull purplish instead of black in color. Abdomen dorsally yellowish brown. Each tergite with a black median line, and two dark brown subdorsal spots surrounded by light areas. The light areas especially prominent on 6. Ventrally white, as opposed to the distinct yellow ventral surface of *humeralis*. The latter has also purplish transverse markings on the venter of the thorax, which are not present in *rubidus*. Outer canines of mandibles rather longer and more slender than in *humeralis*.

Holotype—Male imago, reared. Flat Creek at Black Mountain, N. C., June 16, 1929. No. 1116.1 in Cornell collection.

Allotype—Female imago, reared. Same location, June 15. No. 1116.2 in Cornell collection.

Paratypes—5 male imagoes, 11 female imagoes. Flat Creek, June 15–19, 1929, and June 29, 1930; Ocona Lufty River, June 22, 1930; Pacolet River at Tryon, July 14, 1930; and Hazelwood July 20, 1930. Nos. 1116.3–18 in Cornell collection.

Imagoes of *humeralis* Morgan have definite orange or brown markings on the venter of the thorax, usually paler in the female. The abdominal tergites, while showing a considerable variation in color, usually have a

rather wide brown band on the posterior margin, widest laterally. The fore femora of the male imago have a distinctly orange or reddish apical band; the foretarsal joinings are black, the tip of the tibia widely black. Mesonotum paler than in *rubidus*. Wings more transparent, veins almost invisible. Eyes of male much larger than in *rubidus*.

This species was found only in the mountain area of the state. Other locations from which it was collected during June and July of 1929 and 1930 are listed below. Swannanoa River; North Fork of Swannanoa River; Rocky Broad River at Lecky Gap; Wayah Creek, near Franklin; Spring Creek, near Hot Springs; and the Pigeon River near Woodrow. Two males, one from Calatoochee Creek, and the other from Allen's Creek near Hazelwood, are probably of the same species but are not included among the paratypes.

Three other species of nymphs of Group I were taken in the state. These I designate as Iron sp. Nos. 1, 2, and 3.

Iron sp. No. 1

The only species of Iron found in the piedmont. Collected from the stream at Cascades, another stream near Danbury, and from a small tributary of the Uharie River. Almost mature nymphs were found by the middle of May. Female nymph 12 mm. in length; male 9 mm. Light reddish brown dorsally when mature. Markings very similar to the nymph of *rubidus*. Gills grey, very faintly tinged with lavender. Tracheae not distinct. White ventrally, the apical abdominal segments faintly washed with yellow.

Iron sp. No. 2

Another species from the mountain region. Taken at Cedar Creek, near Glenville, in late June and early July. Female nymph 12 mm. in length; male, 10 mm. The four large white blotches on the frontal margin very prominent. Rather dark reddish brown when mature. A wide dark brown mid-dorsal band is present on tergites 3–5 and 7–8. Black median line and dark brown subdorsal markings, as in previous species. Gills light grey, sometimes with purplish tinge. Tracheae not distinct. Bands on femora not as distinct as in *rubidus*. White ventrally, apical abdominal segments yellowish. One nymph shows traces of brown longitudinal marks parallel to lateral margin. In this species, the outer postero-lateral spines are considerably shorter than in others of Group I, but still noticeably longer and more pointed than those of Group II.

Iron sp. No. 3

Taken from a tributary of the Pigeon River at Waynesville, in late July. Seems distinct from *rubidus*, but has very similar markings. Female nymph 12 mm. in length, male 10 mm. Gills light purplish in color; tracheae dull purple, about as distinct as in *rubidus*. Ventrally pale; apical segments faintly yellow.

Iron dispar, sp. nov.

A representative of Group II. Nymph chestnut brown dorsally, yellowish ventrally. Wing veins of imagoes distinctly brown in apical half. Abdomen of male pale, semi-hyaline. Thorax yellowish brown. Purplish brown markings. Fore tibia dark brown washed with purple.

	SIZE		
	BODY	WING	TAILS
Male imago	9	9	23
Female imago	11–11½	11–12½	23–29

Male imago

Head—Pale yellowish brown. Margin of clypeus, edge of median carina, and streak at inner corner of eye, purple. Small purplish dots between antennae, and below base of each. Vertex with purple spot at center of posterior margin. Eyes about same size as *rubidus*. Base of antenna pale; filaments dusky, tips pale.

Thorax—Yellowish brown. Pronotum purple on anterior margin and at center of posterior margin. Purple subdorsal line on each side. Mesonotum with somewhat darker median band, bordered by pale yellow. Mesonotal spine dark brown. Metanotum dark brown, somewhat paler laterally. Pleura yellowish. Purple streak on anterior coxa and antecoxal pieces. Purple marks on other coxae, also before and behind each coxa. Venter pale yellow; mesosternum pale brown.

Legs—Fore femur yellowish brown. Usual purple median spot; apical marking pale. Tibia purplish brown, darker apically. Tarsus pale yellow, joinings widely purplish. Last tarsal segment dusky. Other legs pale yellowish white, with purplish femoral spot, and very narrowly darker at apex of tibiae and at tarsal joinings. Claws of all legs dissimilar.

Wings—Veins and cross veins in apical half of fore wing light brown; those of basal half almost colorless. In hind wing, apical subcostal cross veins and a few intercalaries on outer margin very light brown, other veins colorless. Stigmatic area of fore wing opaque white. Humeral cross vein purplish black in half next to subcosta.

Abdomen—Segments 2–7 yellowish white, semi-hyaline. Tergite 1, and segments 8–10 yellow, opaque. Posterior margin of each tergite purplish, widest at center. Purplish black mid-dorsal line on posterior half of tergites 1–9. Lateral purplish streak on each, between median line and lateral margin. Purple mark at stigma. Lateral markings on tergites 1 and 2 more extensive than elsewhere. Ventrally unmarked, except for two short purple transverse bars on each side of median line on anterior margin of sternite 2.

Tails—Dusky; faintly tinged with yellow. Unmarked.

Genitalia—Penes quite similar to *humeralis* and *rubidus*, but completely lacking lateral projections. In this respect, similar to *punctatus* McD. Apical margin of subanal plate of a different type from any North American species thus far figured. See Figs. 10 and 13.

The male paratype lacks the lateral purple streaks on the tergites, and the tranverse marks on sternite 2, and is also paler than the holotype, from which the description is drawn.

Female imago

Quite similar to male. All veins distinctly dark brown. Humeral cross vein dark purple its entire length. Abdomen orange, paler ventrally. Stigmatic marks often very faint. Posterior margins of tergites as in male, but on tergites 1 and 2 supplemented by another purplish red band just anterior to the margin. Apical extension of sternite 7 pale brown, margined with purplish. Some of the paratypes are much paler on head, thorax, legs, and tails, and lack the brown mark on sternite 7.

Nymph

Chestnut brown dorsally, pale yellow ventrally.

Head—White median streak runs forward from median ocellus. Frontal margin pale, no darker markings.

Legs—Femoral markings consist of the usual purplish black median spot, and four brown longitudinal streaks, two in basal and two in apical portions. Tibiae wholly pale, except for narrow blackish distal mark. Tarsi pale brown basally; purplish in apical third.

Abdomen—Lateral margins widely white. Posterior margins of tergites narrowly dark. Dark mid-dorsal line, and brown sub-dorsal spots. Pale areas surround subdorsal spots only on tergite 6. Tergites 9 and 10 pale yellowish, darker only beside median line.

Gills—Light grey, frequently tinged with purple. Tracheae indistinct.

Holotype—Male imago. Allen's Creek, near Hazelwood, N. C., July 24, 1929. No. 1117.1 in Cornell collection.

Allotype—Female imago. Tributary of Pigeon River west of Hazelwood, N. C., July 25, 1929. No. 1117.2 in Cornell collection.

Paratypes—One male imago, eight female imagoes; reared. Allen's Creek, July 24, 1929; small stream on Cowee Mountain, July 4–10, 1929, and July 28, 1930; Waynesville, July 16–20, 1929; and Scott's Creek near Balsam, July 23, 1929. No. 1117.3–11.

This species was also collected in the Pigeon River near Woodrow, and in a tributary of the Swannanoa River flowing through the Blue Ridge assembly grounds. Two males, not included in the paratypes because the wing veins are almost wholly pale, have very similar genitalia. These specimens were taken at Waynesville and Penrose, N. C., in July.

Iron sp. No. 4

Another representative of Group II. Collected by Professor Needham from Forney's Creek, Great Smoky National Park, August 26, 1931. Nymph more slender and darker in color than *dispar*. General color dark reddish brown. Body of female, 10–12 mm.; tails 14 mm. Male, 8–8½ mm. in length. Pale median streak anterior to median ocellus. Legs with usual median purple spot on femora. Mainly dark smoky brown in color; light areas limited to base, apex, and lateral streak on femur, and apex of tibia. Thorax pale ventrally; two purple transverse bars on anterior and posterior margins of mesosternum. Abdomen dark reddish brown dorsally. Each tergite has the posterior margin blackish; black mid-dorsal streak and dark brown subdorsal spots. These spots, on 6, surrounded by lighter area. Tergite 9 pale in posterior half. Ten has a pale mark on each side of median line. All tergites tend to become darker laterally, but leaving lateral extensions light. Ventrally pale; in female, usually flushed with pink. Posterior margins often very narrowly dark. One specimen has faint brown lat-

eral blotches. Gills olive-brown with distinct purple tinge. Tracheae quite numerous; very dark purple.

Genus RHITHROGENA Eaton 1881

Six species of this genus are represented in my North Carolina material. Of these, one was found in the piedmont, at one location only; the other five occurred in the mountain area. As far as I am able to determine, all of these are new species. The size alone would seem to indicate this. All six are relatively small species, smaller than *impersonata* McD. and barely as large as *anomala* McD. and *jejuna* Etn. There remains the possibility that one of the North Carolina species may be *jejuna* Etn. Two of these forms I designate by number, as they are represented only by nymphs.

Although nymphs of four of the North Carolina species were fairly abundant, it was very difficult, in some cases impossible, to rear them. Careful comparative study of these nymphs shows a remarkable structural similarity in all six species. Color differences are practically the only means of distinguishing one from another. In life, these color differences are much more striking than in alcoholic specimens. Unfortunately, my field notes on the color of the living nymphs are too brief to be of much value.

Structural characters of the nymphs of this genus have been discussed in my paper on the Heptageninae of North America. I might add that, in all the seven species studied, three teeth are found on the inner margin of the claw near the tip, and one larger tooth or spine near the base. Postero-lateral angles of the abdominal segments are not prolonged into spines. The posterior margin of the pronotum is more or less emarginate, sometimes quite deeply cut. Irregular scroll-like markings are present on each side of the pronotum, and usually on the mesonotum as well.

In the following key, I have endeavored to distinguish these six species, by color alone, in the nymphal stage. No attempt is made to distinguish the imagoes, as too few are known fully in that stage.

Key to Rhithrogena nymphs—N. C. species

1. Tergites 1–8 pale yellow, unmarked.............................sp. No. 1
   Tergites 1–8 not entirely pale, usually central and apical ones darker........ 2
2. Tergites 7–9 yellow, contrasting sharply with central and apical dark tergites..3
   Tergites 7–9 not differing markedly in color from central tergites although usually somewhat lighter..4

3. Tergites 1–6, and basal half of 7, dark reddish brown. Middle portion of head dark brown .... *fuscifrons*
   Tergites 1 and 2 pale yellow, 3–6 dark reddish brown, 7 wholly pale. Middle of head yellow, or shaded with very light brown .... *exilis*
4. Dorsum of abdomen light chestnut or cinnamon brown .... *uhari*
   Dorsum of abdomen orange or orange brown 5
5. Tergites 4–8 dark brown basally, with pale posterior margins, thus appearing to be banded .... *fasciata*
   Tergites of 4–7 entirely dark brown; 8 and 9 yellowish brown, with yellow subdorsal marks. Do not appear to be banded .... sp. No. 2

From the piedmont area

Rhithrogena uhari, sp. nov.

This species was found only in the piedmont, in Caraway Creek. This stream, which is a tributary of the Uharie River, flows through the Uharie Mountains. Collections were made not far from the small town of Sophia, in April and May of 1929 and 1930.

Nymph

Size—Body of male nymph, 5–6 mm.; of female 6–7 mm. Tails 4 mm.

General color—In life, light chestnut to cinnamon brown dorsally, without conspicuous markings. Gills forming a prominent grey fringe around the abdomen.

Head—Ocelli black-ringed, eyes black. A light area near each ocellus. Antennae yellowish. Indistinct light transverse bar near center of vertex. Seven pectinate spines on crown of maxilla.

Thorax—Indistinct brownish scroll-like markings on pronotum, and a more or less distinct dark transverse band near center. Very faint markings on mesonotum. Anterior margin of mesonotum, and a small spot at each side of median line, dark brown. Ventrally pale whitish.

Legs—Pale yellowish white. Femora faintly washed with brown; usually not banded nor barred. Very faint round purplish spot near center of each femur, and numerous small brown spines on upper surface. Tarsus yellowish brown at each end. All joinings dark brown.

Abdomen—Each tergite very narrowly brown on both anterior and posterior margins. In general, uniformly chestnut brown in color. Faint traces of an oblique light mark on each side of median line at anterior margin, and of a small light spot on each side of median line near center of tergite. Tergite 10 often slightly darker than others.

(One specimen has tergites 8 and 9 yellowish.) Ventrally, pale yellowish white.

Gills—Light grey. Filaments same color.

Tails—Pale yellow.

Female imago

Size—Body 6 mm.; forewing 7 mm.; tails 8 mm.

General color—Pale yellowish; the anterior abdominal tergites banded with purplish.

Head—Black mark below each antenna. Base of antenna white. Basal portion of filament dark, remainder light brown. Faint brownish markings above frontal margin.

Thorax—Pronotum and mesonotum pale yellowish. Small dark spot near center of lateral margin of pronotum. Faint purplish shadings near wing roots, on mesonotum. Brown shading on each side of mesonotal spine. Metanotum yellowish brown, darker posteriorly. Pleura paler than notum. Purplish marks below each wing root, and faint dark lines above middle and hind legs. Ventrally pale, the mesosternum washed with yellow.

Legs—Pale whitish. Small round black spot at center of each femur. Tarsi somewhat smoky, with black spot dorsally at each joining. Claws black at base and tip, and narrowly along upper margin.

Wings—Semi-hyaline, whitish (tending to look distinctly milky). Pterostigmatic area with milky cloud. All veins white.

Abdomen—Dorsally light yellowish brown. Tergites 1–5 with purplish posterior margins. Tergites 6–10 more washed with yellow, not banded. Pleural fold whitish. Ventrally pale yellow, unmarked. Apical extension of 9th sternite very slightly emarginate at center.

Tails—Pale yellow, unmarked. Joinings opaque.

Holotype—Female imago, reared. Caraway Creek, the Uharie Mountains, N. C., May 13, 1929. No. 1118.1 in Cornell collection.

Paratypes—Female subimago, reared. Same data. 20 nymphs, same location, April 20, 1929. No. 1118.3–23 in Cornell collection.

Nymphs that seem similar to those from Caraway Creek were collected near Hillsville, Va., on May 4, 1929. No others were found at any other station in North Carolina.

From the mountain region

Rhithrogena exilis, sp. nov.

Nymph

Size—Body of male nymph, 4½-5 mm.; of female, 5–6 mm. Tails 4 mm.

General color—Pale yellow with dark brown markings and bands.

Head—Frontal and lateral margins pale whitish. Central area between eyes yellow. In a few specimens, head shaded with light brown. Antennae very pale yellow. Lateral ocelli long, roughly comma-shaped. Nine pectinate spines on crown of maxilla.

Thorax—Pronotum deeply emarginate on posterior margin. Dark brown, with few scroll-like yellow markings. Meso- and metanota, and wing cases, yellow. Faint brown marks on each side of median line, on anterior margin of mesonotum. Few faint irregular brown marks anterior to wing roots, and at joinings of wing-cases to one another. Ventrally pale yellowish white.

Legs—Pale yellowish white, marked with dark brown. Each femur has customary dark median spot, and two wide dark brown transverse bands, one near each end. Spines on upper surface also dark brown. Tibia and tarsus rather smoky, the tarsus somewhat darker. Basal end of tibia dark.

Abdomen—Tergites 1 and 2 pale yellow, unmarked. Tergites 3–6 dark reddish brown, unmarked; lateral extensions yellow. Tergites 7–9 yellow, unmarked. Tergite 10 brown in apical half. Ventrally, sternites 1 and 2 pale; 3–6 light brown; 7–9 pale, the latter tinged with yellowish brown apically. Some nymphs have brown marks at anterior margins of central segments, and posterior margins narrowly dark.

Gills—White or very pale grey. Filaments light purplish grey.

Tails—Pale yellow. Narrowly light brown at joinings.

Female imago

Size—Body 6 mm.; forewing 7 mm.; tails broken.

General color—Body yellow. Abdomen tinged with pink.

Head—Black half-ring at base of each antenna. Black spot on each side, underneath clypeus.

Thorax—Purplish black irregular mark laterally on pronotum. Faint darker markings on pleura. Ventrally unmarked.

Legs—Purplish black median mark on each femur. No other markings.

Wings—Semi-hyaline. Cross veins of stigmatic area show some anastomosis, as is usual. Veins colorless.

Abdomen—Posterior margins of tergites 2–4 narrowly dull purple. Segments 2–6 flushed with ink or orange. Venter pale, unmarked.

Tails—White, unmarked.

Male subimago

General color—Orange-brown.

Head—Marked as in female.

Thorax—Dark brown comma-shaped mark on each side of mesonotum, just anterior to spine. Brown lines run forward from these marks. Pleura with dark marks above each leg. Mesosternum margined with dark brown.

Legs—Dark mark on each coxa, and at each joining of foreleg, as well as median femoral mark.

Abdomen—Dark orange-brown, the posterior half of each tergite somewhat darker.

Wings and *tails* dark smoky brown. Genitalia not sufficiently developed to be certain of their form.

Holotype—Female nymph. North Fork of Swannanoa River, N. C., June 14, 1929. No. 1119.1 in Cornell collection.

Paratypes—Female imago, reared. Flat Creek, at Black Mountain, N. C., June 13, 1930; 3 female subimagoes, reared, same location June 22–24, 1930; male subimago, reared, same location, June 20, 1929; 20 nymphs, same location, June 17, 1930. Nos. 1119.3–27 in Cornell collection.

A nymph which seems similar to those taken at the above stations was found in the Cullasaja River near Franklin, N. C., on July 3, 1929.

Rhithrogena fuscifrons, sp. nov.

Nymph

Size—Body 5–5½ mm.; tails 6 mm.

General color—Very similar to preceding species. Reddish brown patch in center of head.

Head—Dark reddish brown in central portion, from ocelli to front margin, and on vertex. Lighter brown between vertex and ocelli. Lateral areas, anterior to compound eyes, pale yellowish white. Lateral ocelli V-shaped; the arms of the V black, the space between them dark grey. Antennae pale. 8–9 pectinate spines on crown of maxilla.

Thorax—Dorsally yellowish brown with dark brown markings on each side of pronotum, between wing bases and anterior to wing roots. Pronotum deeply emarginate on posterior border. Wing buds orange brown. Ventrally pale yellowish white. In some nymphs, the general dorsal color is somewhat darker brown.

Legs—Pale yellowish. Coxae brown. Femora with usual purplish median spot, rather small. Fore margin of femur brown, and brown band near apical end. More or less shaded with brown in basal half and sometimes along hind margin. Spines brown, not present on apical half. Tibia pale. Tarsus pale smoky.

Abdomen—Segments 1–6, and basal half of 7, dark reddish brown; paler ventrally. Apical half of 7, and 8–10, yellow. In some specimens, apical half of 10 tinged with light brown. Lateral extension orange-brown.

Gills—White. Filaments light purplish grey.

Tails—Yellowish, narrowly dark brown at joinings.

Female imago

Size—Body 5 mm.; forewing 7½ mm.; tails 8 mm.

General color—Light orange-brown.

Head—Small black spot at base of each antenna. Posterior margin of head brown. Antennae dark brown basally, the tips lighter.

Thorax—Posterior margin of pronotum, and its lateral areas, tinged with purplish. Spines of meso- and metanota, and lateral margins of these spines, tinged with purplish. Pleura paler with a few purplish marks, and a dark streak above the fore and middle legs. Pale ventrally, the posterior portion of the mesosternum as dark as the notum.

Legs—Yellowish, the tibiae and tarsi somewhat smoky. Usual dark purple mark near center of each femur. All joinings dark brown.

Wings—Semi-hyaline. Veins pale yellow, cross veins faint.

Abdomen—Tinged with purplish brown dorsally, darker on tergites 2–6. Posterior margin of tergites very narrowly dark purplish. Pale ventrally.

Tails—Pale whitish. Joinings very narrowly dark.

Holotype—Female nymph. Tributary of Pigeon River, four miles west of Hazelwood, N. C., July 21, 1930. No. 1120.1 in Cornell collection.

Paratypes—Eight nymphs. Same data as holotype; Rocky Broad River at Bat Cave, N. C.; tributary of the Ocona Lufty River, July 12, 1929; tributary of the Cullasaja River near Franklin, N. C., June 24, 1929. No. 1120.3–10.

Immature nymphs were also taken from the Ocona Lufty River on June 22, 1930, and from the Cullasaja River on July 3, 1929.

I had at first taken this species to be identical with the preceding one. But the quite constant color differences, as well as the difference in the time of maturing, lead me to believe that this species is distinct.

Rhithrogena fasciata, sp. nov.

Nymph

Size—Body 5½–7 mm.; tails 5–7 mm.

General color—Orange, marked with dark brown. In life, appears orange and black.

Head—Dark orange-brown, laterally somewhat lighter orange. Four small white spots on vertex, much as in sp. No. 2. Antennae light brown, 10 pectinate spines on crown of maxilla.

Thorax—Pronotum very deeply emarginate on posterior margin. Pronotum shaded with orange. Remainder of notum rather smoky brown. Irregular lighter marks, also darker brown ones, on pro- and mesonota. Ventrally, pale yellowish. Narrow black transverse bar on mesosternum.

Legs—Pale yellowish white. Femora marked with light brown; darker at apex. Tibiae whitish. Tarsi slightly smoky.

Abdomen—Reddish brown marked with yellow. Lateral extensions dark brown. Large yellow area next to dark margin, bounded on inner side by another dark streak. Triangular brown lateral areas on each tergite, extending inward to median line on tergites 1–3. Tergites 4 and 7 dark brown in basal two-thirds, yellow apically. Tergites 5 and 6 all brown except narrow yellow dorsal line and narrow posterior margin. Anterior tergites thus appear to be banded, 8 and 9 yellow except for narrow dark band on anterior margin; 10 dark brown, with narrow yellow anterior margin. Ventrally, light yellowish brown. Each sternite narrowly dark brown on posterior margin. Traces of lateral and oblique subventral lighter streaks on each sternite.

Gills and filaments silver-white.

Tails—Yellowish white. Joinings narrowly dark brown.

Male imago

Size—Body 6 mm.; forewing 6 mm.; tails 10 mm.

General color—Pale yellowish.

Head—Pale yellow. Edge of clypeus colorless, transparent. Small

black spot at base of antenna. Small black spot beneath clypeus on each side. Purplish area around base of antenna. Base of antenna white. Filament smoky, tip white.

Thorax—Pronotum deeply emarginate posteriorly. Yellowish orange in color. Mesonotum pale yellow. Brown area on each side of mesonotal spine. Metanotum brown. Pleura pale with ochreous markings. Venter pale ochreous, the posterior half of the mesosternum distinctly tinged with brown.

Legs—Yellowish brown, femora deeper brown. Round purplish spot at center of each femur; not elongate (thus resembling *anomala* McD.). All joinings narrowly dark purplish.

Wings—Semi-hyaline. Longitudinal veins yellowish to yellowish brown; cross veins colorless. Cross veins in stigmatic area show some anastomosis.

Abdomen—Pale smoky, with ochreous tinge on some segments. Segments 1 and 2 pale, very faintly smoky. Segments 3–6 deeper smoky, with definite lavender tinge. Posterior margins of all tergites dull pale lavender, thus giving a banded appearance. Indistinct lighter subdorsal dashes and a light median line on tergites 2–7. Segments 7–10 tinged with pale ochreous. Paler ventrally. Ganglionic area colorless; banding not apparent.

Genitalia—Pale brown in color. In form, quite close to *anomala* McD., but differing in minor details. See Fig. 5.

Tails—Whitish; unmarked.

Holotype—Male imago. Waynesville, N. C., July 17, 1929. No. 1121.1 in Cornell collection.

Paratypes—Four male subimagoes, reared. Same location, July 16, 1929; and 12 nymphs, same data. No. 1121.3–18.

This species was found also at Flat Creek near Black Mountain; in the Cullasaja River; in Bald Creek, west of Burnsville; and in a tributary of the Rocky Broad River near Bat Cave.

Rhithrogena sp. No. 1

Nymph

Size—Body 5 mm.; tails 4 mm. (immature nymph).

General color—Pale yellow with dorsum of thorax and tergites 9 and 10 dark brown.

Head—Pale, except posterior margin of vertex and posterior portion of lateral margins, which are brown. Ocelli as in *fuscifrons*. Antennae pale. 7–8 pectinate spines on crown of maxilla.

Thorax—Brown dorsally, unmarked. Ventrally pale greyish. Pronotum very slightly emarginate on posterior border; much less deeply cut than in *exilis* or *fuscifrons*.

Legs—Pale. Usual small purplish spot on femora I and II; absent or very indistinct on femur III. Femora faintly brown apically. Narrow black line near basal end of tibia. Small brown spines present on basal half of femur.

Abdomen—Segments 1–8 pale yellow; 9 and 10 dark brown.

Gills—White. Filaments very pale grey.

Tails—White. Joinings very narrowly yellowish brown.

I have only nymphs of this species, and these not yet fully mature. It is much less common than any of the preceding species. Nymphs were found in the Ocona Lufty River on July 12, 1929; in a tributary of the Davidson River, July 9, 1929; and in the Laurel River near Hot Springs on June 29, 1930. In each case, only one or two nymphs were seen.

Rhithrogena sp. No. 2

Nymph

Size—Body 7 mm.; tails broken.

General color—In life, bright orange dorsally. Alcoholic specimens orange-brown.

Head—Dark orange-brown. Four small white spots on vertex, two on each side of center. Anterior pair wider apart than others. White line from corner of compound eye to outer margin of head. Antennae light brown.

Thorax—Pronotum rather deeply emarginate on posterior margin. Orange-brown dorsally. Few scroll-like brown markings on pronotum, and on mesonotum between wing buds. Dark brown transverse band across center of pronotum. Anterior margin of mesonotum dark brown, also dark brown at wing joinings. Ventrally pale.

Legs—Femora brown, with prominent white longitudinal streak, near apical end of which is the usual purplish spot. Brown spines present in basal half. Apical end of each femur darker brown. Tibiae much paler, rather smoky brown, with narrow dark band near basal end. Tarsi and claws similar in color to femora.

Abdomen—Orange brown dorsally, the lateral extensions paler brown. Tergites 4–7, and 10 except at base near median line, darker brown than others. Tergites 8 and 9 yellowish brown, each with two yellow subdorsal streaks. Faint indications of these streaks occur on 4–7. Ventrally pale brown, sternite 9 darker. Posterior margins of sternites narrowly dark brown. Traces of pale lateral lines and oblique subventral dashes.

Gills—Greyish, with faint lavender tinge at base. Filaments purplish grey.

Tails—Yellowish brown, joinings narrowly dark brown.

Nymphs of this species were taken from the Rocky Broad River at Lecky Gap on June 23, 1930. A quite similar nymph, probably of the same species, was found in the Laurel River on June 29, 1930. No adults of this species were obtained. The species is not common, only a few nymphs being found in each location named.

Genus STENONEMA,* gen. nov.

Of all the Heptagenine mayflies of the state, the members of this genus were by far the most common. In numbers of species found, it also exceeds all others in this group. Representatives of the genus were taken in each of the three regions of the state, and many species were reared from the nymphs. My collection from North Carolina includes 16 species, distributed as follows: from the coastal plain, 2 species; from the piedmont, 9 species; and from the mountains, 9 species.

As stated in my paper on the Heptageninae of North America, the species of this group appear to fall into three distinct groups. These groups I have termed the *interpunctatum* group, the *vicarium* group, and the *tripunctatum* group. At the time of writing the above-mentioned Heptageninae paper, the nymph of *carolina* was not known to me. Recently I have reared this species from nymphs taken in the vicinity of Ithaca, N. Y. This nymph is so similar in structural details to those of the *interpunctatum* group that I do not now consider this species as

* The word Stenonema is neuter gender. It has reference to the thread-like character of the 7th gill of the nymph. The genus includes those North American species formerly placed in Ecdyonurus.

In the male imago, the first fore tarsal joint is $\frac{1}{3}$ to $\frac{2}{3}$ the length of the second. Genitalia somewhat resemble those of species of the European genus Ecdyonurus. Cross veins of the stigmatic area of the fore wing are not anastomosed, thus differing from Ecdyonurus. The seventh gill of the nymph is a slender tapered thread or filament.

I designate *tripunctatum* Bks. as the type of the genus.

representing a fourth group within the genus, a possibility I had suggested because of the genitalic differences of the male.

There are, however, good grounds for the belief that the *interpunctatum* group is quite widely remote from the other two groups, which are rather closely related. When Eaton figured the nymphs of this genus in the Revisional Monograph, he placed the nymph of the *interpunctatum* group (Pl. 57) in a separate genus from the nymph of the *vicarium* group (Pl. 58). It is quite possible that further study of this difficult but interesting genus will show that the *interpunctatum* group is indeed worthy of generic rank apart from the *vicarium-tripunctatum* groups. For the present, I leave all these three groups in the one genus.

The *interpunctatum* group may be subdivided into (1) species related to *interpunctatum* and *frontalis*, and (2) into species allied to *carolina*. The *vicarium* group, likewise, may be subdivided into (1) those species resembling *vicarium* and *pudicum*, and (2) those related to *pulchellum*, *terminatum*, and *integer*. If I am correct in the belief that *luteum* Clem. is a member of the *tripunctatum* group, that group will also show two divisions: (1) the species allied to *tripunctatum*, and (2) those allied to *luteum*.

The characters of these groups and their subdivisions may be summarized as follows:

I. *Tripunctatum* group (*tripunctatum* Bks., *femoratum* Say, probably also *luteum* Clem. and perhaps *medio-punctatum* McD.).

Nymphs—Claws with two pectinations. Gill of 7th pair with trachea present, its outer margin hairy. Gills 1–6 rounded at tip. Spines on abdominal segments 5 and 6 about equal in length to that on 7. Spine on segment 9 equal to or longer than that on 7.

Imagoes—Genitalia of the *tripunctatum* type (see Fig. 14). Many cross veins of the fore wing often heavily infuscated, especially at and below the bulla. At bulla, cross veins of costal, subcostal, and radial spaces closely crowded together, some often rather oblique. Hind wing dark-bordered, in first two species. In male foretarsus, 1st joint equals 5th, 1st is one-half or more of 2nd, 3rd slightly longer than 2nd, 4th equals 2nd.

II. *Vicarium* group.

A. *Vicarium* division (*vicarium* Wlk., *pudicum* Hagen, *fuscum* Clem., *ithaca* Clem. and Leon.).

Nymphs—Claws without pectinations. No trachea in gill of 7th pair, its margin very hairy. Gills 1–6 oblong or truncate at tip. Spines on abdominal segments 5 and 6, if present, very short—always shorter than that on 7. Spine 9 variable in length in relation to that on 7.

Imagoes—Genitalia of the *pudicum* or *vicarium* type (see Fig. 12). Few to many cross veins in fore wing infuscated, usually most at and below bulla. Cross veins of first three or more spaces crowded together at bulla. Hind wing may be dark-bordered. Venter of abdomen may be marked. In male foretarsus, 1st joint equals 5th, 1st equals ½ of 2nd, 3rd equals 2nd, 4th about ⅔ of 3rd.

B. *Pulchellum* division (*pulchellum* Wlsh., *ruber* McD., *bipunctatum* McD., *terminatum* Wlsh., *placitum* Bks., *rubromaculatum* Clem., *varium* n. sp., *annexum* n. sp., *exiguum* n. sp., *bellum* n. sp., and perhaps *subaequalis* Bks.

Nymphs—Claws with two pectinations. Spine of segment 9 equal to, or shorter than, that on 7. Otherwise similar to nymphs of *vicarium* group.

Imagoes—Genitalia of *pulchellum* or *terminatum* type (see Figs. 16 and 4). Only a few veins, or none, in fore wing, infuscated, not noticeably more so at bulla than elsewhere. No crowding of cross veins at bulla. Foretarsus of male similar to that of *vicarium* group, except that 1st joint may be ⅓ to ½ of 2nd, or more than ½ of 2nd, and 4th may be ¾ of 3rd. In *integer* and *exiguum*, hind wing is narrowly dark-bordered. Genitalia of *pulchellum*, *ruber*, *annexum*, *varium*, and *rubromaculatum* are of the *pulchellum* type; other species have genitalia of the *terminatum* type.

III. *Interpunctatum* group.

A. *Interpunctatum* division (*interpunctatum* Say, *canadensis* Wlk., *frontalis* Bks., *affine* n. sp., *pallidum* n. sp.)

Nymphs—Claws without pectinations. Trachea present in gill of 7th pair, apparently not forked. Fine hairs on margin of 7th gill. Gills 1–6 pointed at tip. No spines on abdominal segments 1–6. Spine on segment 9 longer than that on 7 which is very short.

Imagoes—Genitalia of the *interpunctatum* type (see Fig. 3). Several cross veins in basal portion of costal, subcostal and radial spaces thickened at center, or in costal space, near costal margin. At bulla, these margined cross veins fully or almost connected by black transverse dash.

Intercalaries in 3rd or 4th space at apical margin may be thickened. Hind wing always dark on outer margin, marginal intercalaries usually black. In male foretarsus, 1st joint equal to or longer than 5th; 1st joint ⅓, ½ or more than ½ of 2nd; 2nd and 3rd about equal; 4th a little more than ½ of 3rd.

B. *Carolina division* (*carolina* Bks.)

Nymphs—Trachea in 7th gill forked at base, thus giving appearance of two longitudinal tracheae. Otherwise similar to nymphs of preceding group.

Imagoes—Genitalia of the *carolina* type (see Fig. 2). No black transverse bar connecting margined cross veins at bulla. A few basal cross veins of costal and radial spaces thickened, those in costal space always thicker at costal margin. In male foretarsus, 1st joint somewhat longer than 5th; 1st equals ½ of 2nd; 4th a little more than ½ of 3rd and about equal to 1st.

Subaequalis Bks. is known to me only by the published description. I am unable to find among my North Carolina material any specimen which meets all the specifications for this species. Because of points mentioned in the original description, the species would seem to be of the *pulchellum* group, although differing from others of that group in the relative lengths of the joints of the male foretarsus.

Specimens in the Cornell University collection which seem to fit descriptions of *luteum* Clem., *mediopunctatum* McD., and *rubromaculatum* Clem. indicate that the first two species are members of the *tripunctatum* group, while the third species is of the *pulchellum* division. Since, however, I have not seen type material of any of these three species, my tentative identifications may be in error.

Key to male imagoes, genus Stenomena—North Carolina species

1. Cross veins in costal and radial spaces, before and at bulla, thickened at center (or in costal space near costal margin) by black marginings 2
   Cross veins in these spaces, if margined, are thickened equally along entire length 6
2. Radial cross veins at bulla connected along center line by a continuous black streak; spinous processes present on outer lateral margins of penes 3
   Black marginings along center of radial cross veins at bulla very thick and prominent, but not connected to form a continuous line; no spinous processes on outer lateral margins of penes .... *carolina*
3. Prominent black longitudinal streak on each side of pronotum 4
   No such black lateral streak on pronotum .... *affine*

4. Black mark of dash present under antenna............................5
No dark mark under antenna............................sp. No. 2
5. Median band present on hind femur—no thickening of 3rd and 4th intercalaries at apex of forewing............................*pallidum*
Median band not present on hind femur—3rd and 4th intercalaries at apex of forewing thickened............................*interpunctatum*
6. Cross veins in three or more spaces at bulla crowded together and heavily infuscated............................7
Cross veins not more crowded at bulla than elsewhere, and not infuscated...9
7. Cross veins in seven spaces at and below bulla crowded together, widely infuscated, and more or less connected by a zigzag brown cloud; hind wing widely darkened on outer apical margin............................*pudicum*
Cross veins at bulla crowded and infuscated in first three spaces only, not connected by a brown cloud; hind wing may or may not be somewhat darkened on outer apical margin............................8
8. Posterior half to two-thirds of abdominal tergites 1–7 largely dark brown; sternites marked with dark tranverse bands; hind wings not darkened on outer margin............................*vicarium*
Abdomen largely white, with a median row of dark spots on posterior margin of tergites; sternites unmarked; hind wings may be faintly darkened on outer margin............................*tripunctatum*
9. Hind wing darkened on outer margin, especially near apex; small species, wing under 7 mm.; tails not marked............................*exiguum*
Hind wing not darkened on outer margin; species varying in size; tails distinctly ringed at joinings............................10
10. Abdominal tergites largely reddish or purplish brown............................*ithaca*
Abdominal tergites largely pale............................11
11. Small species, wing under 9 mm............................12
Larger species, wing 10 mm. or over............................13
12. Thorax wholly pale; oblique dark streak at stigma of each abdominal segment *bellum*
Thorax reddish brown dorsally; stigmatic dots (not streak) present on segments 3–6............................*ruber*
13. Red stigmatic stain present in forewing; dark posterior margins of tergites widest at mid-dorsal line............................*annexum*
No red stigmatic stain in forewing; dark posterior margins of tergites even in width............................*varium*

Key to Stenonema nymphs—North Carolina species

1. Gills 1–6 pointed at tip; spines present on posterolateral angles of abdominal segments 7–9 only............................2
Gills 1–6 rounded or truncate at tip; spines present on posterolateral angles of abdominal segments 5–9............................6
2. Wide pale submedian longitudinal streaks on dorsum of abdomen............................3
Dorsum of abdomen unicolorous except for very narrow pale submedian pencillings............................5
3. Large nymphs, 9–11 mm.in length; yellowish brown or grey in color, the dorsal abdominal markings yellow............................*carolina*

Smaller nymphs, about 7 mm. in length; reddish brown in color, the abdominal markings whitish....4
4. Only two pale longitudinal streaks on dorsum of abdomen....sp. No. 2
Two wide submedian and two narrower lateral pale streaks on dorsum of abdomen....*affine*
5. Nymphs 9–11 mm. in length....sp. No. 1
Nymphs smaller, 6–7 mm. in length....*pallidum*
6. Gills 1–6 rounded at tip; trachea present in 7th gill....*tripunctatum*
Gills 1–6 truncate at tip; no trachea present in 7th gills....7
7. Claws with two pectinations....8
Claws not pectinate....10
8. Large stout nymphs, 10½ mm. or more in length....9
Smaller nymphs, under 10 mm in length....*ruber*
9. Abdomen dark reddish brown dorsally, with conspicuous pale lateral patches on middle segments; venter usually unmarked, except for lateral streaks on 9....*annexum*
Abdominal tergites 6 and 10 largely dark, others with many pale markings; conspicuous black markings usually present on sternites 8 and 9....*varium*
10. Abdominal segments with conspicuous wide black posterior border, extending completely around each segment....*vicarium*
No such continuous black border on abdominal segments....11
11. Nymphs usually not over 10 mm. in length. Conspicuous black crescentic markings on sternites 4–9; tergites 6, and 8–10, largely dark, others with many pale markings....*ithaca*
Larger nymphs, 12 mm. or more in length. Ventral markings inconspicuous; tergites dark reddish brown, none conspicuously darker than others.... 12
12. No conspicuous white markings on abdominal tergites; white bands on femora discontinuous....*pudicum*
Conspicuous white V-shaped markings at median line of tergites 5, 7, 8 and 10; femora with continuous white transverse bands at center and near distal end....sp. No. 3

From the coastal plain

Stenonema interpunctatum Say ?

These specimens are larger than indicated for *interpunctatum* in Say's original description, and vary somewhat in marking from those which I am considering closest to the true *interpunctatum*. However, as I do not yet know how much variation, both in size and coloration, may occur in this species, I place these specimens tentatively in *interpunctatum*. Males of this species measure 8½ to 9 mm.; wing same; tails 26 mm. Vertex of head reddish yellow, marked with black on median line, and with a dark spot on each side. Black spot at center of median carina; a black dash below the antenna; very small black spot at lower corner of each eye. Bar in wing continuous over 2 or 3 cross

veins (except in one specimen, where the bar is absent). Fourth intercalary in apical margin somewhat thickened. Tails indistinctly banded with pale brown at joinings. No stigmatic dots. Other characters as indicated in Say's description. Genitalia shown in Fig. 3.

These specimens were taken in flight by Prof. Needham on April 11, 1929; several individuals were captured from Goshen Swamp in Duplin County and others from Chicod Swamp in Pitt County.

Stenonema annexum, sp. nov.

Somewhat resembles *rubromaculatum* Clem.; in abdominal markings, much like *mediopunctatum* Md. Distinguished from the latter by the type of genitalia, the distinctly banded tails, the pale thorax, in details of color of legs and wings, and in having fewer cross veins in wings. Somewhat larger than *rubromaculatum*. The description of that species is too inadequate, however, to be certain whether or not this species is synonymous with it.

Size—Body of male imago, 8½–9 mm.; wing 10–11 mm.; tails 22–27 mm. Body of female, 8½–10 mm., wing 11–13; tails 17.

Male imago

Head and thorax pale brownish to clay-colored. Abdomen hyaline whitish except last three segments, which are opaque and tinged with yellow. Reddish stigmatic area.

Head—Indistinct narrow dark line across center of median carina (not present on one specimen). Vertex dull purplish brown, often with a dark brown spot on each side. Antennae faintly dusky.

Thorax—Geminate dark purplish brown median line on pronotum. Fore and hind margins narrowly purplish black. Purple streak on pleura, extending down on base of foreleg. Ochreous markings on pleura. Wide median whitish band on mesonotum, including scutellum. Dark brown lateral shading on metanotum. Dark brown patch on fore coxa; another wide oblique brown streak just back of foreleg.

Legs—Fore femur dusky, tinged distinctly with yellow. Other legs yellowish white. All femora with median and apical purplish bands. Fore tibia widely black at apex, others narrowly ringed with black apically. All tarsal joinings narrowly yellowish brown. Claws dark brown basally. First foretarsal joint about ½ the length of the second (not more than ½ its length).

Wings—Hyaline, iridescent. Longitudinal veins yellowish, especially

those on the costal border. Cross veins thicker than longutidinal; dark reddish brown in color. Humeral cross vein particularly thickened. 5–6 costal cross veins before the bulla, about 11 beyond. At bulla, 2 cross veins in costal space, 2 or 3 in subcostal space. Stigmatic area with reddish stain in most specimens. Veins of hind wing almost colorless.

Abdomen—Distinct stigmatic dots present on tergites 2–8 (less prominent on 2 and 8). Tergites 1–6 with very narrow dark posterior margins, thickest at the median line, thus giving the appearance of dark transverse median dorsal marks. These most prominent on tergites 3–6. Venter pale, unmarked.

Genitalia—See Fig. 16.

Tails—White. Alternate segments narrowly ringed with purplish black, except at base, where the first 6 or 7 segments are often not marked.

Female imago

In general, similar to male, except for usual differences of sex. Posterior margins of tergites somewhat more distinctly and regularly dark than in male.

Nymph

Size—Body (female) 10½–11½ mm.; tails 17–18 mm.

General appearance—Dark reddish brown dorsally; legs and tails distinctly lighter in color than body. Head and abdomen with numerous tiny light dots on dark areas.

Head—Frontal area dark reddish brown; margin fringed with hairs. Lateral margins colorless except for a narrow dark band from eye to outer margin. Vertex and occiput lighter brown, with white areas next to eyes, and a large whitish diamond-shaped area at center.

Thorax—Two dark brown longitudinal bands on each side of pronotum. One extends obliquely forward on each side of median line. The other and outer band, quite irregular in outline, lies near the outer margin and extends forward so that its anterior end almost touches the inner band. Lateral margin pale yellowish. White blotches laterad of the outer dark band, and between the two dark bands. A few small light marks near wing bases, on mesonotum.

Legs—Pale yellowish. Femora with 3 irregular dark brown transverse bands and a small dark spot near center of band nearest base of leg. Two dark bands on each tibia. Tarsi light brown in basal half. Tips of claws brown. Claws with 2 small pectinations.

Abdomen—Dark reddish brown dorsally; tiny dots most numerous on lateral areas. Dark median stripe extends length of dorsum. Tergites 2–7 have a blackish spot on each side, half-way to lateral margins, and posterior to the middle of each tergite. Anterior to this dark spot is a large white area, bounded by dark brown, extending forward and outward. Thus the sides of the tergites next to the gills appear white-blotched, with dark dots below. Anterior margins of 4–5 and 8–10, irregularly and narrowly white. Lighter area on each side of dark median line on tergites 4–5 and 7–9. Short lateral spines on 7–9; the spine on 9 shorter than on 8. Ventrally pale yellowish red. One specimen shows faint lateral brown streaks on each sternite, faint dark median marks at anterior margin of each, and an oblique brown mark on each side of 9. All other nymphs are unmarked ventrally.

Gills—Light greyish purple. Thread-like seventh gill unusually long and slender.

Tails—Pale greenish yellow; in mature nymph, shaded basally with light brown.

Holotype—Male imago. Goshen Swamp, N. C., April 11, 1929. Collector, Prof. J. G. Needham. No. 1122.1 in Cornell University collection.

Allotype—Female imago. Same data. No. 1122.2 in Cornell collection.

Paratypes—3 male imagoes, 9 female imagoes; 2 male sub-imagoes, 3 female subimagoes. Goshen Swamp and Chicod Swamp, April 11, 1929. Same collector. No. 1122.3–19 in Cornell collection.

Included among the paratypes are a male and female imago, slightly smaller and paler than the others, and in which the stigmatic area is opaque whitish with no trace of red. In other details they are similar to the remainder of the paratypes. Nymphs were collected from several small tributaries of the Cape Fear River near the little village of Buies Creek, and from tributaries of the Neuse River near Ft. Barnwell, in April 1930. Two female imagoes reared from these nymphs seem similar to those from Goshen and Chicod Swamps.

From the piedmont

Stenonema pallidum, sp. nov.

A small slender species from the Cascades, near Danbury. Nymphs were collected on May 12, 1929, and on May 18, 1930. Several imagoes of both sexes were reared. This species is close to the one I am calling

interpunctatum Say, but is considerably paler, and the third femur has a distant median band.

Male imago

Size—Body 6½–7 mm.; wings 7½–8; tails 20–22 mm.

Head—Pale yellowish. Black dash below each antenna. Small reddish spot in center of vertex. Base of antenna white. Basal portion of filament faintly dusky, tip pale.

Thorax—Notum pale, yellow to yellowish brown. Pleura slightly deeper yellowish. Black longitudinal stripe on each side of pronotum. No other markings. Yellowish ventrally, with deeper orange area at each side near base of third leg.

Legs—Yellowish white. Fore femur yellowish brown with conspicuous purplish black median and apical marks. Similar but paler marks on 2nd and 3rd femur. Fore tibia purplish black at apex. Joinings of fore tarsus very faintly brownish, as is apex of last tarsal joint of other legs. One claw brownish, on all legs. Fore leg about as long as body.

Wings—Hyaline, iridescent. Basal cross veins of costal, subcostal, and radial spaces, and a few beyond bulla in same spaces, black and thickened. Other cross veins rather dark brown, those in basal half of wing rather pale. Dark dash in wing short, dumb-bell-shaped, including one or two cross veins. Fourth apical intercalary narrowly darker than others. 4 to 5 cross veins in costal space, before bulla; 2 oblique ones at bulla, and about 12 beyond. The first two of these are widely separated. Outer intercalaries of hind wing dark.

Abdomen—Whitish. 1–7 semi-hyaline, 8–10 opaque, faintly yellowish dorsally. Each tergite rather widely margined posteriorly with purplish black. No stigmatic dots. Unmarked ventrally.

Genitalia—Very similar to those of the species I believe to be the true *interpunctatum* Say. A small protuberance on each side of the inner margin of the penes, present in all species of *Stenonema*, seems to be turned outward occasionally, as is the case in the specimens of this species.

Tails—Pale, unmarked.

Female imago

Size—Body 6–7½ mm.; wing 9–10; tails 17.

Cross veins of forewing somewhat darker and more prominent than in the male, especially in the basal half. Small black dot on face at lower

corner of each eye, as well as black dash below antenna. On vertex, a black spot on each side, in addition to central reddish dot. Otherwise similar to male.

Nymph

Size—Body 6–7 mm.; tails 10–11 mm.

General appearance—Slender light reddish brown nymph. Abdomen paler dorsally than head and thorax. Abdominal tergites narrowly dark-ringed. Median pale streak on dorsum of abdomen.

Head—Bright reddish brown, especially in central area anterior to ocelli. A narrow, light line from outer corner of eye to lateral margin; epicranial suture also narrowly white. Anterior to median ocellus a small white spot, and a somewhat larger one laterad of each lateral ocellus. Antennae pale brown.

Thorax—Notum bright reddish brown. Antero-lateral angles of pronotum pale, also one or two small spots on each side. Mesonotum also mottled with small light spots. In mature nymph, a black bar on each side of pronotum is evident. Median suture of mesonotum pale. Ventrally, pale yellowish. Narrow dark line at posterior margin of mesosternum; small brown spots at each side between 2nd and 3rd legs.

Legs—Yellow to pale yellowish brown. Femur with brown median band and darker apex. Tibia smoky, paler at each end. Tarsus dusky, apex pale. Claw dark-tipped.

Abdomen—Pale reddish brown dorsally. Each tergite narrowly purplish black on posterior margin. Central paler median streak, bounded on each side by a very narrow paler line, shaped thus: ( ). No other dorsal markings. Short postero-lateral spines on 8 and 9, about equal in length. Anterior segments pale laterally, beneath gills. Ventrally pale yellowish. Lateral margins of 7–9 pale brown; no other markings.

Gills—Dark greyish purple; tracheae distinctly dark purple.

Tails—Pale yellowish brown. Near base, short dark spines at every joining; beyond base, spines at every 2nd or 4th joining. No spines in distal half. In central part, alternate joinings narrowly darker.

Holotype—Male imago, reared. The Cascades, near Danbury, N. C. May 21, 1929. No. 1123.1 in Cornell University collection.

Allotype—Female imago, reared. Same locality, May 21, 1930. No. 1123.2 in Cornell collection.

Paratypes—2 male imagoes; 1 female imago; 5 male sub-imagoes; 5 female sub-imagoes; 8 nymphs. Same locality, May and early June, 1929 and 1930. Nos. 1123.3–23. In Cornell collection.

Stenonema sp. No. 1.

Nymphs very similar in color pattern and general appearance to those of *S. pallidum*, but about ⅓ longer, and relatively more slender, were taken at the Cascades in May, 1930. Females only were reared. These are very much like females of *S. pallidum*, but slightly larger, and with no black mark beneath the antennae. Cross veins of the wings are somewhat less numerous. Body of female imago, 10–11 mm.; wings 11 mm.; tails 25 mm. Nymphs measure 9–11 mm., tails 14 mm. In most of these nymphs, no dark posterior border is present on the tergites. In alcohol, they are pale reddish brown in color, but in life appeared much darker brown.

Stenonema affine, sp. nov.

A pale species, lacking the dark dash beneath the antennae and the dark stripe on the pronotum. No median band on femur of second leg.

Male imago

Size—Body 7–8 mm.; wing 8–9 mm.; tails 18 mm.

General appearance—Pale whitish, the thorax and tip of abdomen creamy yellow.

Head—Pale yellowish. No dark spot on face below antenna. Small dark spot at lower corner of each eye. No dark spot on median carina. Vertex with a small central reddish spot and two dark lateral dots. Antennae dusky.

Thorax—Entirely pale creamy yellow with faint pinkish tinge. No dark lateral streaks on pronotum. Some of the sutures of the notum and pleura are *very narrowly* darker.

Legs—Whitish, the fore leg tinged faintly with yellowish brown. Fore femur with median band and black marks at apex. Other femora lacking the median band, and the apical markings very faint. Apex of fore tibia, and last foretarsal joint, brown. Claws and tarsal joinings of all legs pale brown.

Wings—Semi-hyaline. Costal cross veins slightly thickened, especially toward the costa. 4 or 5 before the bulla, 13 or 14 beyond it;

of these, the first two are widely separated, the next five close together, the remainder more evenly spaced. 3 subcostal and 2 radial cross veins at bulla, the latter connected by the customary dark dash. Fourth intercalary on apical margin not thickened. All longitudinal veins pale. Cross veins brown, paler in basal half of wing.

Abdomen—Segments 1–8 semi-hyaline, white; 8–10 opaque, tinged with yellowish. Posterior margins of tergites marrowly purplish black. No stigmatic dots.

Genitalia—Differ but slightly from the coastal plain species.

Tails—White basally, the extreme distal portion very faintly smoky. Unmarked.

Female imago

Similar to male except for usual differences. Costal and radial cross veins before the bulla rather more widely margined than in the male. Body 7 mm.; wing 9 mm.; tails 12 mm. (may be broken at tip).

Nymph

Size—Body 7 mm.; tails 15 mm.

General appearance—Small slender nymph. Light reddish brown color, the head particularly reddish. Abdomen dorsally with 6 longitudinal white stripes.

Head—Bright red-brown. Anterior to median ocellus, a large white mark shaped like a mayfly's hypophyarnx. Another large white mark laterad of each lateral ocellus. Lateral margins pale yellowish, with narrow central brown band. Small light dot on each side of frontal border. A median and two lateral light spots on occiput. Antennae pale brown.

Thorax—Wide pale mid-dorsal band the length of the thorax; widest at anterior margin of pronotum. Pronotum white on lateral margins except anterior angle, which is brown. Remainder of pronotum brown except for three parallel transverse white dashes on each side. Few small light marks on mesonotum near wing roots. Ventrally whitish, with transverse brown band across the mesosternum.

Legs—Pale brown. Femur pale yellowish at each end, and with a pale central band. Tibia white apically, and a white band near basal end. Apical half of tarsus white.

Abdomen—A wide longitudinal white band the length of the abdomen on each side of the brown median dorsal streak. These pale bands somewhat irregular, since the brown median streak is widest at center of

each tergite. A narrow light line on each side close to the lateral border, and between this and the central wide light bands, another narrow light line. Postero-lateral spines on 8 and 9, about equal in length. Ventrally yellow, prominently bordered and marked with reddish brown. Sternite 9 brown except a semi-circular area on anterior margin at median line, and a narrow light area on each side. Wide brown band extends longitudinally on each side of venter, its inner margin widest near center of each sternite. On 6 and 7, inner extensions of these lateral brown bands meet, forming a more or less complete transverse band near center of each of these sternites.

Gills—Light greyish purple. Tracheae distinctly dark purple.

Tails—Brown for short distance at base; remainder yellowish, very narrowly dark brown at alternate joinings. A circle of stout dark spines at each pale joining.

Holotype—Male imago, reared. Caraway Creek, Uharie Mountains, N. C., near Sophia, April 23, 1930. No. 1124.1 in Cornell University collection.

Allotype—Female imago, reared. North Fork of Potomac River at the Smoke Hole, W. Va., Aug. 9, 1930. No. 1124.2 in Cornell University collection.

Paratypes—2 male imagoes, Smoke Hole, W. Va., Aug. 8, 1930; 2 male subimagoes, Caraway Creek, N. C., May 21, 1930; 3 nymphs, Caraway Creek, May 20, 1930; 2 nymphs, Smoke Hole, W. Va., Aug. 7, 1930. No. 1124.3–11.

Nymphs of this species were found also in small streams near Denton, N. C., on June 10, 1929, and near Spero, N. C., on April 29, 1929. The markings of the head and pronotum of the nymph, and its bright reddish brown color, serve to distinguish it from other species having the abdomen prominently striped.

Stenonema tripunctatum Bks.?

Two nymphs, not quite typical of *tripunctatum* Bks. but very similar, were taken from a small stream near Spero, on Feb. 18, 1930. These nymphs possess the row of dark spots on each side of the venter of the abdomen, but the spots are lacking on sternite 9. A male imago was reared from one of these nymphs. Its abdomen, while marked as in typical *tripunctatum* specimens, is washed with brown much as in

femoratum Say. The hind wings are distinctly dark bordered. Genitalia are typical for *tripunctatum* Bks. See Fig. 14. A female nymph similar to those taken at Spero was found in the Uharie River near Farmer. It transformed on April 7, 1929. The brownish wash of the abdomen and the dark-bordered hind wings are present on this specimen also.

Stenonema vicarium Wlk.

Nymphs which seem to be those of *vicarium* Wlk. were taken at four different localities in the piedmont. Dates of collection are as follows. From a small stream near Spero, mature nymphs were taken on Feb. 21, 1930, and on March 1 and 29, 1929; from the Uharie River near Farmer, on April 3, 1929; from Caraway Creek near Sophia, April 13, 1930; and from a stream near Asheboro, in middle April, 1929. Two female and male imagoes were reared from these nymphs. The imagoes are considerably paler than typical *vicarium* imagoes which I have reared from the vicinity of Ithaca, N. Y., so much so that I had thought them to be of a different species. Careful comparisons of the North Carolina material with nymphs and imagoes of the New York specimens lead me to believe, however, that my North Carolina species is in reality a light-colored form of *vicarium.* The venation is considerably paler in the Carolina specimens, the cross veins being dark brown only in the costal margin, and light brown elsewhere in the wing. In the New York specimens, on the other hand, all cross veins are so dark a brown as to appear almost black. Other characters, both of nymphs and imagoes, are very similar for the two forms, aside from the lighter color already noted, of the southern specimens. The genitalia are likewise very similar.

Stenonema pudicum Hag.?

Female imagoes, captured as they flew over the water while ovipositing, are in my collection from the Cascades near Danbury. These females were taken on May 3, 1930. The stream which flows through the Cascades is apparently a tributary of the Dan River, cutting a small gorge through a portion of the Sauratown Mountains. From nymphs collected in this stream on May 18, 1929, and May 3 and 18, 1930, several other females were reared, also one male imago and two subimagoes. The males are unusually small for the size of the females, and much paler in color.

The nymphs differ somewhat in color pattern from nymphs of *pudicum* Hag. taken in the mountain area of the state. I had thought that the Cascades specimens represented a different species. However, there are so few differences, both in nymphs and imagoes, between these and the mountain specimens which Dr. McDunnough has kindly identified as the true *pudicum* Hag., that for the present I place all of them in this species. As the nymph of *pudicum* does not seem to have been described, I present a description of it In listing the species from the mountain localities, the differences between the nymphs will be indicated. I make brief mention also of the differences found between the imagoes of the piedmont and mountain regions.

Nymph (from Cascades)

Size—Body (female) 12–14 mm.; tails 18–20 mm.

General appearance—A smooth-appearing nymph, rather stout. Reddish brown dorsally, without conspicuous markings. Ventrally pale, the apical segments yellow, and marked with dark brown.

Head—Numerous small light dots sprinkled over dark areas. Lateral areas light, with rather wide brown central band from eye to outer margin. Paler spot in front of each ocellus; a small dark spot behind each lateral ocellus. A pale area on each side of the posterior margin of occiput; small light area on median line. Basal segment on antenna largely light; next two dark brown, remainder light brown.

Thorax—Dark brown triangular area, its base on margin, occupies center of anterior margin of pronotum. On each side of this, a narrow white strip, then another dark brown area extending almost to the lateral margin. Enclosed in this dark area is an oblong white patch. Lateral margins pale except for brown streak in central portion. Posterior border narrowly dark, widest at median line. A small light comma-shaped mark is often present on each side, near posterior border. Mesonotum with four darker patches on anterior margin. Irregularly marked with small light and dark areas. Ventrally pale yellowish, sutures light brown.

Legs—Femur largely reddish brown, with three zigzag white bands, often incomplete. Each end is light in color. Tibia reddish brown except for white apical band. Base and apex of tarsus pale; central area dark brown. Tips of claws dark. Claws not pectinate. In fully-mature nymph, a purplish spot in center of each femur.

Abdomen—Each tergite narrowly dark on posterior margin. Dark area along anterior half of median line, on most tergites. A white

sub-median streak on each side of this dark portion, most evident on 5 and 7–10. Irregular light area along anterior margin of each tergite. On 1 and 2, this occupies most of the tergite. A lateral dark patch on each side of each tergite, adjoining the gills. Usually some small white areas near this. Postero-lateral spines present on 3–9, short on 3–6, longer on 7–9; longest on 8. Spine on 9 almost as long as that on 7. Ventrally yellow, this color deepening apically. Faint brown lateral streak on each side of venter. Sternite 9 has a wide dark brown longitudinal streak on each side, extending the length of the segment. Anterior ends of these bars usually connected by a transverse band, which dips down slightly at median line. Oblique dark brown subventral dashes on all sternites. Areas between these filled in with solid brown, in shape of a sector of a circle, on sternites 6–8, and faintly on 4–5.

Gills—Dark purplish grey.

Tails—Greenish yellow, becoming brown basally in fully-mature nymph. Distal half barred with dark brown, these bars being 2 to 3 segments in width. Tail segments very short, especially near base. Joinings dark brown. Circle of long dark spines at each joining basally; in middle of tail, spines at alternate joinings; none present in distal half.

Imagoes

Female imagoes differ from the mountain specimens of the species as follows. Head not so definitely bordered with purple on the posterior margin. Thorax more ruddy before the forewing, and sometimes lacking the cream-colored area next to the mesonotal spine. Tergites of abdomen entirely lacking the median dark sagittate streak. Their posterior margins narrowly and regularly dark, without the purplish wash on the posterior half of the segment, as found in the mountain specimens. Wings somewhat longer and slightly wider, the cross veins slightly darker and more prominent.

Male imagoes are much smaller in size, much paler, and in general differ from the mountain forms as do the females, except that the venation is definitely paler. Genitalia very similar to the mountain specimens.

In addition to the specimens taken at the Cascades, others of the same species were found near Greensboro. Both nymphs and imagoes from this locality resemble the mountain forms much more closely than do those from the Cascades. Nymphs are much less prominently marked ventrally, often having only the oblique dark subventral dashes.

Specimens were collected in April, 1929, and several female imagoes reared.

Stenonema ruber McD.?

This species is not quite identical either with *ruber* McD. or *pulchellum* Walsh, according to specimens of each of these species which Dr. McDunnough has kindly sent me for comparison. In some respects it is intermediate between the two, but in the appearance of the wings in particular it is closer to *ruber* McD. Nymphs, while very similar to those of *ruber*, show some rather constant differences in color pattern. It does not seem advisable to describe these specimens as a new species, however, but rather to place them tentatively in *ruber*, which species they most resemble.

A comparison with typical specimens of *ruber* McD. is added below.

Male imago—Somewhat smaller in size. Paler in color, particularly the thorax and terminal segments of abdomen. Abdomen usually semi-hyaline white, without smoky tinge. Stigmatic area of forewing opaque white, no trace of reddish stain. Purplish streak running down on base of foreleg, usually present. Tails in some specimens without dark joinings. Stigmatic dots and dark bands on posterior margins of tergites usually present, but one or both may be absent. Cross veins in costal area of forewings slightly thicker and darker than in *ruber*. Veins of hind wing, and of outer margin and lower portion of forewing often almost colorless. Other cross veins brown, very similar to *ruber* and less numerous than in *pulchellum*. Legs pale yellowish white, only the fore femur slightly deeper yellow, and much paler than in either *ruber* or *pulchellum*. Brownish or purple tinge at distal end of each femur. Distal ends of 1st and 2nd tibiae dark brown. Median purplish band on femur sometimes indistinct or absent on hind leg. In fore tarsus the first joint varies in length in different specimens from about $\frac{1}{3}$ of 2nd joint to $\frac{1}{2}$ or almost $\frac{2}{3}$ of the second. It may thus vary on the two fore legs of the same insect. In many males of this species, the fore leg is long in proportion to the body, sometimes exceeding it slightly in length.

Nymph—Considerable variation in amount of pigmentation of dorsal surface, which is either light yellowish or dark reddish brown. Extent of the dark ventral markings is also variable. A typical nymph of the yellowish brown variety, well-marked ventrally, compares with a typical *ruber* nymph as follows. Gills very faintly grey (in *ruber*, dark purplish

grey). Hind margins of femora and tibiae bear much shorter hairs than in *ruber*. Abdominal spines and pale ventral surface similar in both. In typical *ruber* a very dark U-shaped mark is present on sternite 9, and a somewhat mushroom-shaped dark mark on 8; all other sternites unmarked. North Carolina nymph has same marks on 9 and 8, likewise a faintly dark dash at center of anterior margin and an oblique subventral streak on each side, on sternites 4 to 7. The mark on 8 is rather that of an inverted mushroom, and the U-shaped mark on 9 is often incomplete on the anterior margin.

Many nymphs of this species were collected, and many imagoes reared. So much variation was noted among these reared imagoes that 25 of the darker specimens were selected for special examination. Of these, 12 were males. Nymphs of these 25 specimens were so similar as to preclude the possibility of two species being involved. Presence or absence of stigmatic dots; of dark bands on the tergites, posteriorly; of dark joinings on the tails; of the color of the thoracic notum; and of the median band on the femur, were the points observed. Results are as follows. One male and 1 female show no slightest trace of dark banding at the tail joinings and in 4 others the banding was very pale. One male has a yellow thoracic notum. Five females show no indications of stigmatic dots, which are very faint on 12 other specimens, of which 5 are males. In 1 male and 2 females, no median band is present on the hind femur. In 1 male and 2 females (same specimens) there is almost no indication of dark borders on the tergites. In several other males, not included in the above specimens, the entire thorax is yellowish clay-color. In most males the terminal segments of the abdomen are yellowish brown, with no trace of darker reddish brown.

So much variation accounts for the great difficulty experienced in determining species accurately when the main characters used to distinguish these species are such variables as darker bands at the tail joinings, stigmatic dots and dark borders on the tergites. Yet it is by a combination of such characters that most species in the *pulchellum* group must be separated. Much rearing work must be done, both in this and the *interpunctatum* group, before the limits of variability can be determined, and species accurately defined.

Specimens of this species were collected from several localities in the piedmont. Imagoes emerged during April and May, likewise in September and early October. No collecting was done in this area between early June and mid-September. The largest number of specimens were found in Caraway Creek, in the Uharie Mountains near Sophia. Other

localities are as follows. Big Alamance Creek, in three different places; Little Alamance Creek at Troxler's Mill; a small stream in the outskirts of Greensboro; a small stream near Spero; the Uharie River near Farmer; Middle Below Creek; and at the Cascades near Danbury, in the Sauratown Mountains.

Stenonema varium, sp. nov.

A rather large species of the *pulchellum* group. Imagoes vary considerably in the amount of dusky tinge present on the abdomen, some being almost wholly pale. Stigmatic dots usually present. Tails white, joinings dark. Abdominal tergites dark on posterior margins.

Male imago

Size—Body 9–11 mm.; wing 10–11 mm.; tails 28–35 mm.

Head—Pale yellowish brown. No marks on frons. Filament of antenna pale brown. Faint orange dot at center of vertex; on each side of this a short curved dusky mark, quite faint.

Thorax—Yellowish brown, darkest on metathorax and on each side of mesothoracic scutellum. Broad whitish areas anterior to wing roots, on pleura between 2nd and 3rd leg, and at base of fore leg. Scutellum of mesothorax white except for a narrow brown median line. Narrow white area immediately anterior to scutellum, and on each side of metathoracic spine. Anterior and posterior margins of pronotum narrowly purplish black. Double median black line on pronotum. Principal sutures of thorax very narrowly dark brown. Sternum very similar in color to notum, slightly darker than pleura.

Legs—Antecoxal pieces brown, coxa and trochanter pale. A purplish streak extends upward on the thorax from the base of the fore leg. Femora pale yellowish, with median and apical purplish brown bands. Tibiae paler than femora, purplish brown at apex. Fore tarsus pale, the joinings very narrowly darker. (In some specimens, entire tarsus faintly dusky.) Other tarsi pale yellowish, the joinings narrowly brown (last joint and claw dusky, in some specimens). First joint of fore tarsus one-half or slightly more than one-half the second joint.

Wings—Semi-hyaline. Both wings have a pale brown cloud near the point of attachment, with pale areas at the extreme costal and anal regions. Brown bands extend forward along the costa and subcosta as far as the humeral cross vein, which is heavily infuscated. No noticeable crowding of cross veins at bulla. Stigmatic area opaque

whitish, without red stain. Costa, subcosta, and radial sector of fore wing yellow. Other longitudinal veins pale yellowish brown. Cross veins dark reddish brown, thicker than the longitudinals. Hind wing very similar, except for entirely pale veins in anal region. 4–5 costal cross veins before bulla, about 8 beyond.

Abdomen—Tergite 1 largely dull purplish grey. Segments 2–6, and basal half of 7, semi-hyaline, white. Apical half of 7, and 8–10, opaque, pale yellowish brown. All tergites with purplish black posterior margins, becoming somewhat wider on the anterior sclerites. Stigmatic dots present on 2–7. On 2–5, a narrow purplish black transverse streak extends from the stigmatic dot laterally almost to the median line, running parallel and close to the dark posterior margin. Median line of tergites 1–3 a dull purplish grey streak, with lateral extensions on each side near the anterior margin. Venter unmarked, the ganglionic track opaque white.

Tails—White. Joinings narrowly purplish brown, alternate joinings wider. Becoming faintly dusky at tip.

Genitalia—Similar in form to others of this group. Forceps silvery white; penes and forceps base pale yellowish brown.

Variations in color pattern—

(a) Abdominal tergites 1–4 largely dull purplish grey, except for pale areas in the anterior lateral angles and a pale band on the anterior margin. Median line bifurcate. Faint dusky area on each tergite bordering the pale pleural joinings. Pale opaque submedian streaks on each tergite may be evident.

(b) Abdomen much paler, the greyish markings of tergites 1–3 or 1–4 almost wholly obsolete. Thoracic notum a somewhat deeper reddish brown. Fore femora, and all segments of other legs, pale yellowish brown. No dusky marks on vertex of head.

(c) Pale specimen, the stigmatic dots practically wanting.

(d) Markings on abdominal tergites 2–3 consist of a grey median line and grey spots on each side of this, in addition to the transverse streak from the stigmatic dot. Faint dusky spot on each side of median carina of face.

(e) Resembles variation (a), but the dusky markings occur on tergites 1–7, although less extensive on 7 and 8 than on the anterior tergites. The purplish median line extends to the tip of the abdomen. Stigmatic dots very small, and directly anterior to each is a pale area

enclosed by a yellowish brown circle. Faint dusky stain on each side of medioventral line, near center of each sternite.

Female imago

Body and wing, 11–12 mm.; tails 28 mm. Head and thorax pale yellowish. No dusky curved marks on vertex. Faint purplish black pencillings above base of each leg. Legs pale yellowish white, marked as in the male. Abdomen pale. Posterior margins of tergites 1–5 narrowly dark; remaining tergites wholly pale. Stigmatic dots present but faint. No median or lateral greyish markings on any tergites. Bases of wings lack the pale brown cloud present in the male. Joinings of tails faintly dark, but paler than in the male.

Variation (a). All tergites narrowly dark on posterior margins. A pale brownish mediodorsal line extends the length of the abdomen. Tergites 1–5 with pale purplish brown shading on each side of median line.

Nymph

Size—Body 9–12 mm.; tails 15 mm.

General appearance—Reddish brown, the abdomen paler than the thorax, and having a banded appearance.

Head—Reddish brown, sprinkled with many minute pale dots. Light areas anterior to median ocellus; laterad of each lateral ocellus; at antero-lateral angles of each eye; and along the lateral margin of the head. Small light areas also at center and on each side of the posterior margin.

Thorax—Reddish brown. Lateral margin of pronotum colorless, except for the brown antero-lateral angle. This pale area extends inward into the surrounding brown border in one or two round emarginations. A large pale spot near center of pronotum on each side. Toward the median line from this spot is a dark area, and a transverse black line passes through the light spot. Young nymphs may have other light areas near the median line at the anterior margin. Pale narrow median line on pro- and mesonotum, widest at anterior margin of mesonotum. A few pale spots on mesonotum near wing roots.

Legs—Pale yellowish. Femora with two wide brown transverse bands, one on each side of middle, and a narrower dark band near each end. Tibia has a brown basal band and another beyond the middle. Tarsus narrowly pale at base and more widely pale at apex, the remaining portion brown. Claws amber, tipped with reddish brown. Each has two pectinations, not very prominent.

Abdomen—Tergites 1–4 very pale yellowish brown, with dark median line in anterior half of each. A dark brown comma-shaped mark, the tail directed anteriorly, is present on each side of the median line near the center, in tergites 3–5, and 7. Tergite 5 like 4, but more yellowish. Tergites 6, 8, and 10 largely dark reddish brown, each with yellow submedian streaks in anterior half. Tergite 8 is likewise yellow on the posterior margin, at center. Tergites 7 and 9 with yellow background and many irregular reddish brown markings. These include a dark median triangle in the anterior half; a variation of the comma-shaped mark; brown lateral margins; and an irregularly triangular brown area occupying a considerable portion of the remainder of each side. Postero-lateral spines are present on segments 3–9; weak on 3 and 4, better developed on 5 and 6, longest on 7–9. Of the latter, that on 8 is slightly the longest.

Ventrally yellow, paler on the anterior sternites. Anterior margin of each sternite very narrowly dark. Postero-lateral extensions brown. Prominent blackish brown markings on the posterior sternites, varying considerably in extent and shape. Typically, a dark brown crescent is present on 9, extending forward to the anterior margin. A median spot occurs at the anterior margin of 8, sometimes divided into two portions connected at the center. On each side of this, a dark spot. In all other sternites, faint brownish oblique submedian streaks arise from the anterior margin, and at the outer end of each (i.e., near center of sternite on each side) is a dark brown dot. Between these and nearer the median line, another faint dot may occur. General appearance is thus of a row of dark dots on each side, in addition to the markings on 8 and 9.

Tails—Greenish in immature nymphs, brown in mature specimens. In distal half to two-thirds of each, groups of 2 to 3 dark segments are interspersed between groups of 2 or 3 pale segments, thus presenting a distinct banded appearance. In basal half, each joining is encircled by stout spines, longer on alternate joinings. Rather long hairs also arise from these joinings.

Genitalia of mature male nymphs dark brown.

Variations in color pattern—

(a) Ventral markings may consist of two dark brown oblique lateral bands on sternite 9, these bands not meeting at the top nor attaining the anterior margin. The rows of dark spots in the other sternites may be faintly indicated, or entirely absent. Dark spot on 8 may be entirely lacking.

(b) Crescentic mark present on 9, and a two-branched mark on 8, but rows of dots on other sternites absent or extremely faint.

(c) The dark mark on 9 may be straight along the anterior margin, thus appearing angular rather than crescentic. Mark on 8 may have the form of an inverted mushroom.

(d) The mark on 8 may be somewhat crescentic, that on 9 likewise a crescent, and another faint crescent may be present on 7.

Holotype—Male imago, reared. Big Alamance Creek at Tom's Place, south of Greensboro, N. C., April 5, 1930. No. 1125.1 in Cornell collection.

Allotype—Female imago, reared. Same locality, April 12, 1930. No. 1125.2 in Cornell collection.

Paratypes—11 male imagoes, 14 female imagoes, all reared. Big Alamance Creek at Tom's Place, April 10–17, 1930; and April 28, 1929; Caraway Creek near Sophia, April 15–27, 1930; near Tabernacle church south of Greensboro, May 1–9, 1930; Greensboro, N. C., April 23–28, 1930; Polecat Creek south of Greensboro, April 9–16, 1930. Also 13 nymphs, from the above localities during April 1929 and 1930; also from the Uharie River near Farmer, N. C., and from a stream 12 miles north of Greensboro. No. 1125.3–40.

This species was more common in the piedmont than any other of the Heptagenine group. In addition to the localities listed for the type material, this species was taken in the following places. Near Spero, N. C., April 29, 1929; at the lake near Liberty, April 23, 1929; near Denton, May 2, 1929; and at Asheboro, April 3, 1929.

Stenonema varium would seem to be rather closely related to *S. rubromaculatum* Clem. Judging by Clemen's description, *varium* may be distinguished from his species by (1) the absence of a red stain in the stigmatic area of the forewing, (2) the larger size, and (3) the greyish median and lateral markings of the anterior abdominal tergites. The nymph is paler, has a more distinct dorsal color pattern, and lacks the extreme hairiness and the granular appearance said to be characteristic of the nymph of *rubromaculatum.*

Included among the typical *varium* nymphs taken at Polecat Creek are some others which are distinctly more hairy. In these, also, the ventral markings of the abdomen are reduced to rows of indistinct dots on all sternites but 9. On this latter sternite, markings consist only of

a lateral dark streak on each side, which is broken up into an anterior and a posterior portion, of which one or the other may be entirely absent. Dorsal markings, while somewhat darker in color, are very similar to those of more typical nymphs, with the addition, in some specimens, of an almost continuous dark median line on the abdomen. Imagoes reared from some of these nymphs are similar to pale specimens of the typical form.

Stenonema exiguum, sp. nov.

See description under species from the mountain area.

A single female imago was taken at the lights of the auto near Hamburg Lake, on June 1, 1929.

Mountain region

Stenonema sp. No. 2.

A single male imago, reared on July 30 from a nymph taken in the Ocona Lufty River, differs from specimens of *S. pallidum* in lacking the dark dash below the antennae. In this respect it is similar to *Stenonema* sp. No. 1 from the Cascades. The nymph is dark reddish brown in color, the lateral areas of the middle abdominal segments being conspicuously pale. The pale irregular subdorsal lines on the tergites are wider, especially on the anterior segments, very much as in nymphs of *S. affine*. Body of male imago measures 7 mm.; wing 8½ mm.

Stenonema sp.

Very elongate dark reddish brown nymphs were found in the Ocona Lufty River on June 22, 1930. No imagoes were reared. These nymphs are somewhat larger and much darker in color then nymphs of *Stenonema* sp. No. 1 from Cascades, and the pale subdorsal lines are almost obsolete. Length 10 to 11 mm.

Stenonema carolina Bks.

A single female imago of this species was caught in flight in the Blue Ridge Assembly grounds near Black Mountain, on June 18, 1929. A tributary of the Swannanoa River flows through the assembly grounds. Another female imago was captured at a small stream on the State Test Farm near Swannanoa on June 18, 1930. An immature nymph, probably of this species, was found in this same small stream. I have

recently reared imagoes of this species from nymphs taken in the vicinity of Ithaca, N. Y. A description of the mature nymph follows. For the genitalia of the male imago, see Fig. 2. The specimen from which the mount of the genitalia was made, was taken from the North Fork of the Swannanoa River, N. C., on May 31, 1912, by Dr. Beutenmuller, and presented to the Cornell collection.

Nymph

Size—Body (male) 9–10 mm.; tails 10 mm.

General appearance—Slender yellowish brown nymph, the brown definitely tinged with grey. Yellow longitudinal stripes on dorsum of abdomen.

Head—Dark reddish brown. Lateral margin yellowish white. A conical white spot anterior to the median ocellus, and another light spot laterad of each lateral ocellus. Posterior margin of head pale, except for narrow dark border on each side of median line. Epicranial suture white. Antennaė purplish grey at base; remainder pale greyish white.

Thorax—Lateral margins of pronotum pale. Large pale circular spot at antero-lateral angle, in which is a small dark spot on anterior margin. Large yellowish white transverse mark on each side of pronotum, widest laterally. Median line pale. Pale spot at median line on posterior margin, another small curved light spot on each side. A black mark may be present on each side near the posterior margin. Mesonotum with pale median streak, widest anteriorly. Few pale marks near wing roots. Pale ventrally, with brown areas in center of prosternum, anterior to bases of 2nd and 3rd legs, and on antecoxal pieces.

Legs—Pale with smoky tinge. Coxa and trochanter each with a brown blotch. Femur pale near each end, and with a narrow irregular median band; otherwise greyish brown. A smoky longitudinal streak near fore margin. Tibia yellowish, with two smoky transverse bands. Tarsus pale distally, basal half pale smoky brown. Claws rather stout; no pectinations near tip, but usual median spine at center on inner margin. Claws tipped with orange-brown.

Abdomen—Dark smoky brown median stripe on dorsum, margined on each side by yellow stripe, which is narrow on tergites 1–6, and progressively wider on 7–10. On 8–10, presents appearance of yellow background with narrow dark median stripe. Lateral margins pale on 1–6. On 7–10, dark brown at extreme magrin, with yellow stripe next to brown. Wide rhomboidal brownish grey patches occupy most of the

remainder of each tergite. In each dark patch is an incomplete yellow streak, and at postero-lateral angles of each, a darker brown spot. General effect is of greyish abdomen with four complete and two incomplete yellow longitudinal stripes. Posterior margins of tergites brown. Long postero-lateral spines on 8 and 9, and shorter spine on 7. Ventrally, pale yellowish white, with lateral brown stripes, widest on sternites 8 and 9. A brown transverse band across the center of sternite 9 connects the two lateral stripes. Posterior margin of 9 brown; anterior margin narrowly brown at middle.

Gills—Pale greyish lavender. Tracheae prominently dark purple. Seventh gill with median trachea and short lateral fringes.

Tails—Yellow with greenish tinge. Alternate joinings narrowly darker. Near base, each joining with a circle of stout dark spines. Further out, spines only at pale joinings. No spines toward tip. Tails fringed with rather long hairs.

Stenonema carolina Bks.?

These two specimens are probably pale forms of *carolina* Bks., as is evidenced by the structure of the genitalia. I found one male at the Blue Ridge Assembly grounds on June 18, 1929. Another very similar specimen was captured by Prof. Needham at Mt. LeConte, Great Smoky National Park, on Aug. 14, 1929. Both males are paler than is typical for *carolina*, somewhat resembling members of the *pulchellum* subdivision. The Blue Ridge specimen has white tails. There are 5 costal cross veins before the bulla, 2 at the bulla, and 11 beyond. Veins brown in the entire forewing. The Mt. LeConte specimen does not have the typical brownish tinge on the costal border of the fore wing, and the veins are much paler in the posterior half of the wing. In both specimens, only two margined radial cross veins are present at the bulla. In both, the first fore tarsal joint is more than $\frac{1}{3}$ but less than $\frac{1}{2}$ the length of the second. Neither specimen has the dark posterior margins of the tergites continued on the sternites, to form continuous dark bands around the abdomen, as is the case in *carolina*. In other respects these males resemble *carolina*.

The body of the Blue Ridge specimen measures 9 mm.; wing 10 mm.; tails 25 mm. The LeConte specimen is slightly larger and stouter.

Stenonema ithaca Clem.

This species and *S. pudicum* Hag. were more common in the mountains than any other species of the genus. Nymphs of *ithaca* were collected

from many stations, and many imagoes were reared. The Carolina specimens are smaller than the spring and early summer nymphs near Ithaca, N. Y., and the imagoes lighter in color; but both nymphs and imagoes are very similar to the mid-summer forms from that locality. Collections were made during June and July of 1929 and 1930. Following is the list of localities from which this species was taken. North Fork of the Swannanoa River near Black Mountain; the Swannanoa River at Black Mountain, and its tributaries in the Blue Ridge Assembly grounds and another near Swannanoa; Flat Creek, another tributary of the Swannanoa; Pigeon River at Cruso; a small tributary of the Pigeon at Waynesville; Davidson River in the Pisgah National Forest; Cullasaja River south of Franklin; French Broad River near Rosman; a small stream near Fairview; Bald Creek west of Burnsville; Laurel River and its tributary near Hot Springs; Spring Creek near Hot Springs; Little River near Penrose; Little River at Cedar Mountain; Ocona Lufty River at Cherokee; Pacolet River at Tryon; Ivy River at Forks of Ivy; and South Toe River at Micaville.

Stenonema pudicum Hag.

Another species which was very abundant in the mountain region. Many nymphs were collected and several imagoes reared. This species was taken at each of the following localities. Pacolet River near Tryon; Little River at Cedar Mountain; a small stream at Waynesville; a tributary of the Pigeon River west of Hazelwood, and another tributary near Waynesville; Ocona Lufty River near Cherokee; Cedar Creek near Glenville; another tributary of the Tuckaseegee River near Glenville; a tributary of the Nantahala River near Wesser; a tributary of the Rocky Broad at Bat Cave, and another near Chimney Rock; Scott's Creek near Sylva; a tributary of the North Fork of the Catawba River near Woodlawn; the Catawba River at Andrews Geyser; Flat Creek at Black Mountain; a small tributary of the Tennessee River at Franklin; two small streams on Cowee Mountain, draining to the Tuckaseegee River; Cullasaja River south of Franklin; and Rock Creek, west of Brevard. They were perhaps most numerous at Cedar Creek near Glenville. Several imagoes were reared from nymphs taken in this stream.

As noted in recording this species from the piedmont, the nymphs and imagoes taken in that region differ somewhat from the mountain specimens, which I believe to be the true *pudicum*. The piedmont

specimens may be varieties, or may perhaps represent a different species. The imagoes from both regions have been contrasted (p. 189). Nymphal differences are noted here.

Nymph (from Cedar Creek)

Differs from nymphs described from the Cascades mainly in the ventral markings, which are much less extensive and less sharply defined in the mountain specimens. Structural features and other color markings are very similar in both forms.

Venter of abdomen reddish brown, darker on the apical segments, especially sternite 9. Rather indistinct brown lateral line the length of the venter, on each side. Oblique dark brown subventral dashes extend outward from the middle of the anterior margin, on each sternite, but the space between these dashes is not filled in solidly with brown, as in the Cascades nymph. Some nymphs show a faint indication of dark brown areas on each side of the midventral line, connected to the oblique dashes anteriorly, on sternite 8. A very dark brown patch occupies the postero-lateral angles of sternite 9, but is not extended into wide longitudinal bars on each side, as in the piedmont specimens. In some nymphs, the distal half of the tail is not barred.

Stenonema ruber McD.?

Nymphs which are apparently identical with those from the piedmont which I am calling *ruber* McD., were collected at two different localities in the mountain and male imagoes reared. The imago from Flat Creek at Black Mountain emerged on June 17, 1930. The other, from a small stream at Camp Carolina near Brevard, emerged July 23, 1930.

Stenonema exiguum, sp. nov.

A species close to *S. integer* McD. Tails unmarked, no stigmatic dots.

Male imago

Size—Body 5½ mm.; wings 6 mm.; tails 15 mm.

Head—Pale whitish, unmarked except for a faint reddish dot at center of vertex. Antennal filament dusky at base.

Thorax—Pale creamy white, unmarked.

Legs—Pale creamy white. Femora with median and apical rose-colored or lavender bands. Tibiae of second and third legs with rose-colored spot near basal end. On fore leg, tibiotarsal joint distinctly

purplish black; tarsal joinings narrowly dark. First tarsal joint slightly more than ½ as long as second. Claws and distal half of last tarsal joint, on all legs, distinctly dusky.

Wings—Hyaline, iridescent. Stigmatic area opaque, with pale but distinct red stain. Cross veins of fore wing prominent, very dark brown. Longitudinal veins on costal margin yellowish brown, remainder pale yellow. Humeral cross vein purplish black. About 4 costal cross veins before bulla, 8–9 beyond. Hind wing narrowly dark brown on outer apical margin. All veins colorless.

Abdomen—White. Segments 1–7 semi-hyaline, 8–10 opaque and washed with pale yellow. All tergites with narrow but distinct purplish black posterior margins. No stigmatic dots. Ventrally unmarked, but ganglionic areas distinctly opaque.

Tails—White; unmarked.

Genitalia—Very similar to *S. integer*. See Fig. 4.

Female imago (from Georgia specimen)

Similar to male, except for usual differences. Cross veins of fore wing relatively darker in color, and longitudinal veins paler, than in male. Body 5½–7 mm.; wings 7–8 mm.; tails 14–15 mm.

Holotype—Male imago. Caught in flight near Woodlawn, N. C., July 16, 1930. No. 1126.1 in C. U. collection.

Allotype—Female imago, Chattahoochee River, Atlanta, Ga., June 10, 1932. Collector, Prof. P. W. Fattig. No. 1126.2 in C. U. collection.

Paratypes—2 male imagoes, Etowah River, Rome, Ga., Aug. 16, 1931. Collector, Prof. P. W. Fattig. 22 females, Chattahoochee River, Atlanta, Ga., June 10, 1932. Prof. Fattig, collector. Nos. 1126.3–26 in C. U. collection.

The holotype, collected near Woodlawn, N. C., probably came from the Catawba River, which is not far distant. The allotype and paratypes, while collected in Georgia by Prof. Fattig during June and August, are so similar to the holotype that there seems no doubt but that they are of the same species. Descriptions and measurements of the male imago are drawn from the holotype.

Stenonema bellum, sp. nov.

Related to *integer* McD., but lacking the dark-bordered hind wing of that species. Oblique dark marks in place of stigmatic dots. A pale whitish species.

Male imago

Size—Body 6½ mm.; wing 7 mm., tails 14 mm.

Head—Pale whitish. A small black dot at inner lower corner of eye, opposite antenna. A narrow reddish line beneath each antenna. Antennae wholly pale. A V-shaped reddish mark on vertex between lateral ocelli. On each side of head near the posterior margin, a large dusky triangular spot.

Thorax—Creamy white. On each side of pronotum, a somewhat oblique purplish red streak, its posterior end continued laterally as a reddish line parallel to the hind margin of the segment. A black line in postero-lateral angle. Prominent oblique purplish black line on pleura of pronotum, extending down to coxa of fore leg. Black pencillings on pleura of meso- and metathorax, anterior and posterior to second and third legs, and extending up between them. Oblique purplish marks on each side of metanotum.

Legs—Pale yellowish white, femora distinctly washed with yellow. Median and apical purplish rose bands on all femora. Purplish rose streak near basal end of each tibia. Tibio-tarsal joining of fore leg faintly dusky. Claws pale brownish yellow.

Wings—Longitudinal veins of costal margin yellowish, all others pale. Cross veins of fore wing dark brown, paler along inner margin. Hind wing wholly pale, without dark outer margin; all veins pale.

Abdomen—Segments 1–7 white, semi-hyaline; 8–10 opaque, yellowish. All tergites narrowly purplish black on posterior margins. Oblique purplish black line near stigmatic region on each side of each tergite, extending forward from each end of the black posterior margin. A double (bifurcate) purplish streak on mid-dorsal line of tergites 3 and 6, in posterior ⅔ of these segments. Faint indications of such a streak on tergites 2 and 7, and a black median dot on posterior margin of tergite 4. Venter unmarked, but ganglionic areas opaque white.

Tails—White. Alternate joinings narrowly ringed with purplish black.

Genitalia—Pale yellowish. Quite similar to those of *exiguum* sp. nov. Forceps relatively longer, both in this species and in *exiguum*, than in *integer* McD.

Female imago

Size—Body 6½–7 mm.; wings 8 mm.; tails 12 mm.

Similar to male except as noted. A small black dot on each side of

median carina, connected to line beneath antenna in one specimen. Laterad of base of antenna, a very small black dot. Markings on vertex and occiput less extensive than in male. On abdominal tergites the black median streaks are wider than in the male. All longitudinal veins pale. Cross veins of costal to median spaces of fore wing pale brown, all others colorless.

Holotype—Male imago. Taken at auto lights, from French Broad River, Penrose, N. C., July 19, 1930. No. 1127.1 in Cornell University collection.
Allotype—Female imago. Same data. No. 1127.2 in C. U. collection.
Paratype—Female imago. Same data. No. 1127.3 in C. U. collection.

Stenonema sp. No. 3.

A species evidently related to *pudicum*, but with a very pale imago. Nymph has a distinctive color pattern. As only females were reared, the species is designated by number only.

Female imago

Size—Body 11 mm.; wing 11–12 mm.; tails 26 mm.

General color—Pale yellowish white.

Head—No markings on frons. Small orange spot at center of vertex, near posterior margin. Small dark mark at inner edge of each eye, near posterior margin.

Thorax—Entirely pale, except for narrow black markings above and in front of the base of the 2nd and 3rd leg, and another above the base of the fore leg.

Legs—Pale creamy white. Indistinct median and apical purplish bands on femora, the median band very faint on the third leg. Apex of tibia, and all tarsal joinings narrowly dark reddish brown. Last tarsal joint dusky.

Wings—Humeral cross vein quite heavily infuscated. Slight crowding of subcostal and radial cross veins at bulla. Stigmatic area opaque white. Longitudinal veins of costal margin yellow; all others pale yellowish brown. Cross veins reddish brown, very distinct and much thicker than the longitudinals. . Those of the basal half narrowly infuscated. Cross veins numerous. Usually 5 costals before bulla, and 14–17 beyond. Hind wing rather widely stained with brown on apical portion of outer margin. Veins pale except along costal and apical margins.

Abdomen—Segments 1–8 semi-hyaline, pale creamy white. Segments 9 and 10 opaque, tinged with yellow. Eggs, when present, give yellow tinge to abdomen. Each tergite with rather broad purplish brown posterior margin. Stigmatic dots present on 3–6. Venter pale, unmarked. Subanal plate broad, with a broad shallow emargination on its apical margin.

Tails—White. Joinings narrowly dark purplish brown.

Nymph

Size—Body 11–12 mm.; tails 19 mm.

General color—Reddish brown, paler ventrally.

Head—Reddish brown. Pale marks anterior to median ocellus and laterad of lateral ocelli. A narrow pale strip from outer anterior margin of eye to lateral border. Postero-lateral angles yellowish.

Thorax—Lateral borders of pronotum pale. A round light spot near center of each side; another at anterior margin on each side of median line; a third paler spot near posterior margin on each side of median line. A rather large pale oblong mark on each side of mesonotum, between median line and wing roots. On each side of this, toward the wing roots, a smaller light spot.

Legs—Femur reddish brown with a median pale transverse band; also pale areas at each end on the hind margin, and basally on the front margin. A small light dot near center in basal half of each femur. Tibia pale, with basal dark brown band and another between middle and apex. Tarsi dark reddish brown except for a narrow pale basal area. Claws pale, tipped with amber. Without pectinations.

Abdomen—Postero-lateral spines on 5–9. Short on 5 and 6. Those on 7 and 9 somewhat longer, and about equal in length. Spine on 8 longest. Reddish brown dorsally, paler on lateral margins of gill-bearing segments. Tergites 1–3, and 9 and 10, largely reddish brown; 10 usually pale along anterior margin, and 9 may have indistinct pale submedian streaks. Tergite 6 reddish brown with pale oblique submedian marks from the anterior margin. Tergites 4 and 5, and 7 and 8, each with a distinctive white V-shaped mark at median line. Point of V is on or near the posterior margin at the median line. Its arms diverge and extend forward on each side of the median line to the anterior margin, becoming somewhat wider anteriorly. In 4 and 5, the anterior end of each arm of the V is extended laterally as a short white transverse mark parallel to the anterior margin. On tergites 5 and 8, the point of the V may be obsolete. Ventrally yellowish to pale yellowish brown.

Sternite 9 may be shaded with brown on the lateral margins. Gills dark purplish grey.

Tails—Greenish yellow tinged with brown. Stout spines encircle the joinings in the basal half, being stouter at alternate joinings except very near the base. In distal half, where the segments are longer than at the base, each segment is crossed by a white transverse band at about the middle of its length.

Five females of this species were reared. Three of these are from nymphs taken in a small stream on Cowee Mountain, between Dillsboro and Franklin. These females transformed on July 8 and 12, 1929. Another is from Franklin, on July 10, 1929, while the fifth, from a small stream near Swannanoa, transformed June 15, 1930.

Nymphs were likewise collected, during June and early July of the summers of 1929 and 1930, from Black Mountain; the Little River at Cedar Mountain; the Catawba River near Andrews Geyser; and a little stream near Balsam. Immature nymphs were taken by Prof. Needham near Stump House Mountain, S. C., and Highlands, N. C., on April 5, 1929. A spent female was caught in flight a few miles west of Selica, near an old mill, on July 13, 1930.

CORNELL UNIVERSITY,
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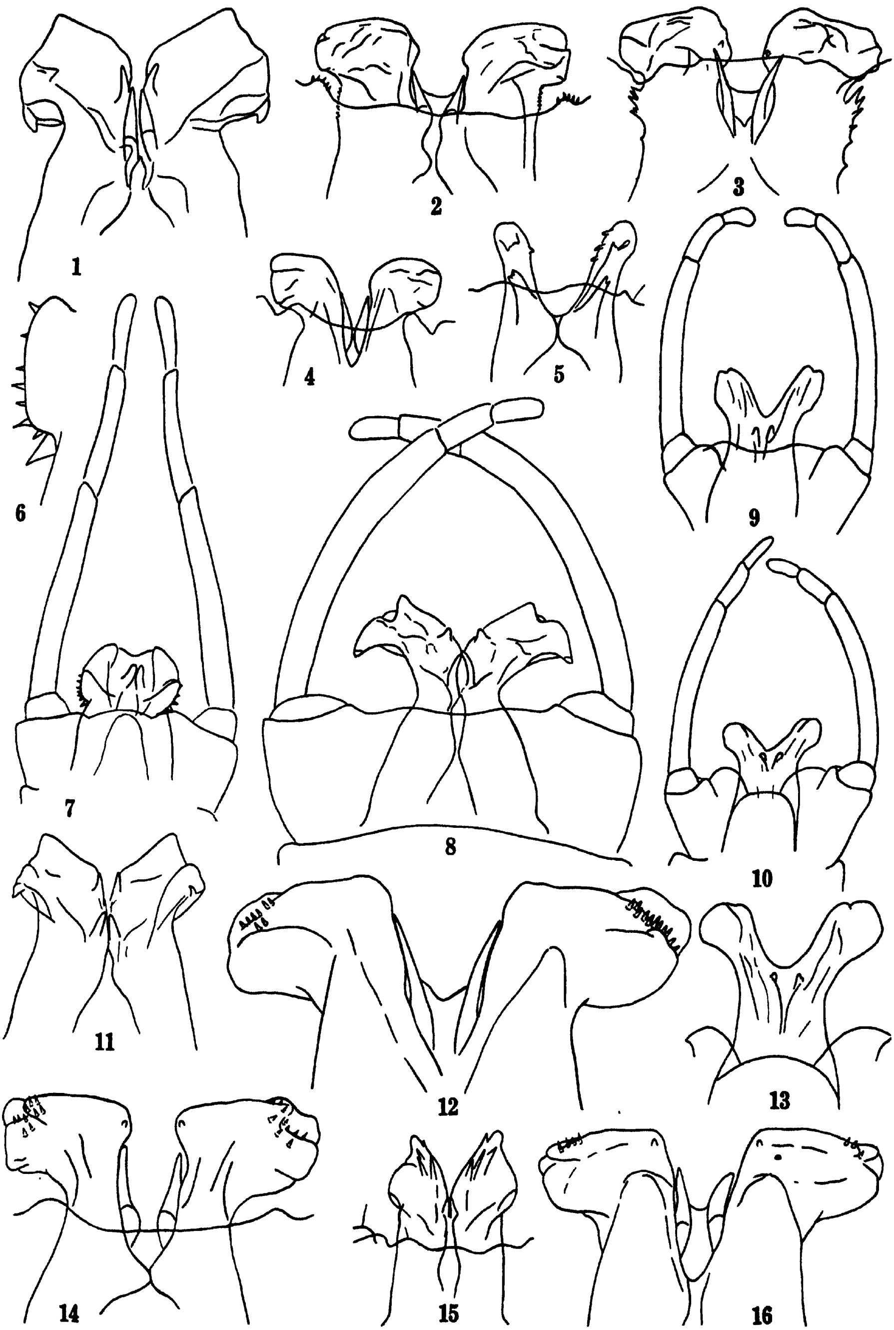
EXPLANATION OF PLATE 15

Fig. 1. *Heptagenia pulla* Clem. Details of penes. (Genitalia of *elegantula* type)
Fig. 2. *Stenonema carolina* Bks. Details of penes.
Fig 3. *Stenonema interpunctatum* Say. Details of penes. (From Goshen Swamp specimen.)
Fig 4 *Stenonema exiguum*, sp. nov. Details of penes. (Genitalia of *terminatum* type.)
Fig. 5. *Rhithrogena fasciata*, sp. nov. Details of penes.
Fig. 6 *Heptagenia spinosa*, sp. nov. Details of one side of penes
Fig. 7. *Heptagenia spinosa*. Genitalia.
Fig. 8. *Heptagenia marginalis* Bks. Genitalia. (Genitalia of the *flavescens* type.)
Fig. 9. *Iron rubidus*, sp. nov. Genitalia.
Fig. 10. *Iron dispar*, sp. nov. Genitalia.
Fig. 11. *Heptagenia julia*, sp. nov. Details of penes.
Fig. 12. *Stenonema pudicum* Hag. Details of penes.
Fig. 13. *Iron dispar*. Details of penes.
Fig. 14. *Stenonema tripunctatum* Bks. Details of penes.
Fig. 15. *Heptagenia aphrodite* McD. Details of penes. (Genitalia of *maculipennis* type.)
Fig. 16. *Stenonema annexum*, sp. nov. Details of penes. (Genitalia of *pulchellum* type.)

PLATE 15



ALGAE OF CHARLOTTESVILLE AND VICINITY

By Ivey F. Lewis, Conway Zirkle, and Ruth Patrick

Plate 16

Charlottesville is located in the piedmont section of Virginia at an elevation of from five to six hundred feet above sea level. It is fairly well watered, having an average annual precipitation of about 46 inches, and being in a region of rolling hills and low mountains is very well drained. There are no ponds or lakes except artificial ones in the region in which the collections were made nor are there any bogs or swamps over a quarter of an acre in extent.

The water in all the small streams and in the Rivanna River is soft and contains a great deal of iron. The city itself is located on the dividing line of two geological regions, the Cambrian and the Algonkian. Most of the collections were made in the former, where the majority of small streams are located. The only collections made in the Algonkian were along the river banks and the larger streams.

The collections were confined to a radius of approximately three miles about the city limits except for the city reservoir six miles to the west and the stream which flows from it. The algal flora is abundant throughout the year. Ninety genera and 249 species were identified, and there were also found a number of species represented by specimens too fragmentary to allow of identification. Four new species are described. The relative number of genera and species in the various groups is as follows:

GROUP	NO. OF GENERA	NO. OF SPECIES	NO. OF VARIETIES
Myxophyceae	22	57	
Chlorophyceae (except desmids)	45	71	1
Desmidiaceae	17	115	14
Heterokontae	4	5	
Rhodophyceae	2	1*	
Total	90	249	15

* (One not identified).

The Conjugales are exceptionally abundant and varied, often as many as 25 species appearing in a single collecting vial. Abundant as they are, however, conjugation is extremely rare, only three instances having been found in a period of seven years.

All except two species identified were preserved either in formalin or on glycerin-jelly or Karo slides and indexed for reference. Camera lucida drawings were made of these two specimens and their identification was checked repeatedly.

The work in 1930–31 was based in part on collections made as usual and in part on studies of the intestinal contents of tadpoles. Miss Farlow[1] found that the algae contained in the alimentary tracts of tadpoles were of many different species, and from this source a good representation of the flora of a pond can be obtained. She used samples from different parts of the alimentary canal. This use of tadpoles as collectors has been found to be a very efficient one, but many more species are obtained if the complete tract rather than portions of it is used. Farlow suggests that the anterior part of the alimentary canal is the best for collecting purposes. This has been found true for filamentous forms, but desmids are distributed throughout the canal and diatoms are especially abundant in the posterior part. During this study both spring and fall collections were made. About 500 slides were made from tadpoles.

One of the most interesting results of this study is the finding of some very long Closteria. A great many specimens were found in the tadpole material whose existence in the ponds was not at first suspected. The long Closteria represent two species whose affinities seem to be with *C. lineatum* and *C. pritchardianum*, though with certain resemblances also to *C. juncidum* and *C. areolatum*. Descriptions will be found at the end of the annotated list of species.

Two species seem to be reported for the first time for the United States. They are *Cosmarium Lundellii* Delp. var. *ellipticum* West, found in Scotland and Wales, and *C. moniliforme* var. *panduriformis* Heimerl., found in Great Britain, Austria, and Australia.

ANNOTATED LIST OF ALGAE (EXCLUDING DIATOMS)

Myxophyceae

Anabaena catenula (Kuetz.) Bornet & Flahault
    Small swamp by Fry Spring road; all seasons; common.

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[1] Farlow, C. V. Biological Bulletin 55 (6): 443–448. December, 1928.

A. inaequalis (Kuetz.) Bornet & Flahault
Small swamp on stream leading from city reservoir; spring; common.
A. irregularis sp. nov.
Old reservoir (see p. 221).
A. oscillarioides Bory
Temporary swamp below abandoned rock quarry on Observatory Mountain; May; rare.
A. variabilis Kuetz.
Swamp in cow pasture below University golf links; March; rare.
Aphanocapsa elachista W. & G. S. West
Filtered from city water supply; October; rare.
Calothrix epiphytica W. & G. S. West
Epiphytic on *Tolypothrix* from city reservoir; late autumn; rare.
C. parietina (Naegeli) Thuret
Swamp above University ice pond; early spring; rare.
Chamaesiphon curvatus Nords.
Still House Mountain stream; March; rare.
Chroococcus minor (Kuetz.) Naegeli
Growing on damp bank of Rivanna River; September to May; common.
C. varius A. Braun
On damp bank near steps of Cabell Hall; September; common.
Clathrocystis aeruginosa (Kuetz.) Henfrey
Swamp by golf links; October; rare.
Cylindrospermum catenatum Ralfs
Swamp in abandoned rock quarry on Observatory Mountain; September; common.
C. majus Kuetz.
On banks of the Rivanna River above the woolen mills; October; common.
C. minutissimum Collins
Swamp on stream from old University reservoir; November; common.
C. minutum Wood
Stream crossing Fry Spring road; November; common.
C. muscicola Kuetz.
Swamp in orchard below University cemetery; December; common.
Gloeocapsa conglomerata Kuetz.
Shaded terrace by west door of Cabell Hall; December; common.
Gomphosphaeria aponina Kuetz.
Swamp in orchard below University cemetery; February; rare.
Hapalosiphon flexuosus Borzi
On bank of University ice pond; February; rare.
Lyngbya aerugineo-caerulea (Kuetz.) Gomont
On the banks of the Rivanna River above the woolen mills; October to May; common.
L. arachnoidea Kuetz.
Stream by Southern freight yards; November; rare.
L. Digueti Gomont
Stagnant pond in University sunken garden; April; rare.

L. gigantea sp. nov.
Swamp by Garth road; March; rare (see p. 221).

L. Martensiania Menegh.
Growing on the damp bank north of Cabell Hall; September to December; common.

L. nana Tilden
Swamp north of the road to the city reservoir; November; rare.

L. spirulinoides Gomont
Small stream by the abandoned rock quarry; November; rare.

L. versicolor (Wartman) Gomont
Swamp in orchard back of University cemetery; March; rare.

Merismopedium aerugineum Bréb.
Swamp in the abandoned rock quarry, strained from top water; September to June; common.

Microcoleus paludosus (Kuetz.) Gomont
Swamp north of golf links; September to December; rare.

M. vaginatus (Vaucher) Gomont
Near steps of Cabell Hall; on soil in open woods; November; common.

Nodularia Harveyana (Thwaites) Thuret
Swamp in abandoned rock quarry; October; rare.

Nostoc commune Vaucher
Near steps of Cabell Hall on north terrace; September; common.

N. cuticulare (Bréb.) Bornet & Flahault
City reservoir, epiphytic on *Nitella*; late autumn; rare.

N. gelatinosum Schousb.
Found growing symbiotically with *Anthoceros* on the road to Monticello; September; rare.

Oscillatoria Boryana Bory
Stream through the barbecue grounds; September; rare.

O. chalybea Mert.
Found in overflow of the old reservoir; April; rare.

O. chlorina Kuetz.
Growing in cistern north of Randall Building; October; rare.

O. limosa Ag.
Found in nearly all small streams about Charlottesville; September to April; very common.

O. princeps Vaucher
Found in gutter along Scottsville road; November to February; fairly common.

O. sancta Kuetz.
In stream along Fry Spring road; February; rare.

O. splendida Grev.
Growing in an old aquarium; January; rare.

O. tenuis Ag.
On mud bank of Rivanna River, exposed during low water; October; rare.

Phormidium corium (Ag.) Gomont
Stagnant pond in University sunken garden; March; rare.

P. foveolarum (Mont.) Gomont
Found in overflow from old reservoir; April; rare.
P. rubrum Tilden
On edge of stream along Fry Spring road; October; rare.
P. subuliforme Gomont
Stream by Southern freight yards; November; rare.
P. valderianum (Delp.) Gomont
Found in overflow of reservoir; April; rare.
Scytonema Hofmanni Agardh
In recently drained portion of Davis Pond; September; rare.
S. Austinii Wood
Under overhanging cliffs of James River; all seasons; rare.
Stigonema minutum (Ag.) Hassall
In Davis Pond; September; rare.
Symploca muralis Kuetz.
On mud bank of Rivanna River; on ground in open woods; all seasons; common.
Synechococcus aeruginosus Naegeli
Swamps in cornfield below University cemetery; March; rare.
Tolypothrix distorta (Hofman-Bang) Kuetz.
Small stream from Kearney's Mountain; March; rare.
T. lanata Wartmann
Old reservoir; September to December, March to May; common.
T. rupestris Wolle
Moist bank on road to Monticello; October; rare.
T tenuis Kuetz.
Swamp in orchard below University cemetery; November to March; rare.

Chlorophyceae and **Conjugales** (Except Desmids)

Ankistrodesmus Braunii (Naegeli) Brunn.
Small streams below Davis Pond; November; rare.
A. falcatus (Corda) Ralfs
Filtered from water of old reservoir; March; rare.
Bulbochaete sp.
In the old reservoir; September to June; very common. As in no instance was fruiting observed a specific identification was impossible.
Chaetophora pisiformis (Roth) Agardh
Stream by abandoned rock quarry; May; fairly common.
Characium sp.
On brown *Hydra*; October; rare.
C. gracilipes Lambert
On Daphnia, pond by Lynchburg road; October; rare.
Chlamydomonas communis Snow
In small temporary spring by golf links, in swamp south of road to city reservoir; September to June; very common.
C. stellata Dill.
Old reservoir; September to December; fairly common.
Chlorococcum humicola (Naeg.) Rabenhorst
Swamp by small stream crossing Fry Spring road; October; common.

C. infusionum (Schrank) Meneghini
Pond on Lynchburg road, two miles south of Charlottesville; February; rare.

Chlorogonium euchlorum Ehrenberg
Swamp by Garth road; April; common.

Cladophora sp.
Growing in old aquarium; January; very rare, not enough found to identify.

Coleochaete divergens Pringsheim
Mixed with *Batrachospermum* in small stream from Kearney's Mountain; March; rare.

C. Nitellarum Jost
Growing endophytically in the cell wall of *Nitella*; November; rare.

C. scutata Bréb.
Old reservoir; September to December, March to June; fairly common.

Crucigenea truncata G. M. Smith
In tap water; March; abundant.

Cylindrocapsa conferta W. West
Swamps by golf links; April; rare.

Dictyosphaerium pulchellum Wood
Swamps below barracks; March; rare.

D. Ehrenbergianum Naegeli
Old reservoir, Sinclair's pond; October; rare.

Draparnaldia glomerata (Vauch.) Agardh
In nearly all small streams, Sinclair's ice pond; September to June; very common.

Eremosphaera viridis De Bary var. *major* Moore
Found in small swamp below University ice pond; October to May; common. Some specimens were as large as 210 microns in diameter. However it is evidently not a new variety as transitional sizes were found between the type form and the largest form.

Eudorina elegans Ehrenberg
Tap water, old reservoir; September to May; never abundant.

Gloeococcus Schroeteri (Chodat) Lemmermann
Swamp below Histological Laboratory; February; rare.

Gloeocystis gigas (Kuetz.) Lagerheim
Swamp in abandoned rock quarry; October; common.

G. planctonica Lemmermann
Pool in University sunken garden; March; rare.

Kirchneriella lunaris (Kirchner) Möbius
Found in old aquarium; May; rare.

K. obesa (W. West) Schmidle
Found in an old aquarium; common in collections of desmids; September to June; common.

Microspora Loefgrenii (Nordst.) Lagerheim
In small stream on the road to the city reservoir; February; rare.

M. Lauterborni Schmidle
Swamp in upper end of University ice pond; March; rare.

M. Willeana Lagerheim
In wet weather spring north of golf links; September to July; common.

Microthamnion strictissimum Rabenhorst
In wet weather spring north of golf links; May; rare.

Mougeotia sp.
Swamp by golf links, old reservoir, Moore's Creek; year round; common. At least three species, but was never found conjugating and consequently no identification was possible.

Nephrocytium obesum West
Tap water; February; rare.

Nitella sp.
City reservoir; year round; abundant.

Nitella sp.
Old reservoir, Chamberlain pool; common.

Oedocladium albemarlensis Lewis
On bank of Rivanna River; September to October; rare.

Oedogonium crenulato-costatum Wittrock
City reservoir growing on *Nitella*; November; rare.

O. grande Kuetz. forma *robusta*
University lagoon; October; rare.

O. mexicanum Wittrock
Old reservoir; October; rare.

O. plagiostomum var. *gracilius* Wittrock
Fish pond on Lynchburg road; September; rare.

O. Reinschii Roy
Old reservoir; October; fairly common.

O. rufescens Wittrock
Old reservoir; October; rare.

Oocystis Borgei Snow
Swamp north of golf links; March; rare.

O. crassa Wittrock
Tap water; September to December; common.

Pandorina morum (Muell.) Bory
In tap water; September to March; common.

Protococcus viridis Ag.
On north side of trees on University grounds; year round; common. A larger form was also found growing on cistern north of the Randall Building. The cells measured 8–11 μ by 10–14 μ. As the genus is at present in such a confused state no new variety was made.

Protosiphon botryoides (Kuetz.) Klebs
Growing on moist banks near door of Cabell Hall; September; rare.

Radiofilum irregulare (Wille) Brunnthaler
Swamp south of golf links; March to June; common.

Scenedesmus arcuatus Lemm. var. *platydisca* G. M. Smith
Old reservoir, Chamberlain and Sinclair's ponds; September to June; common.

S. bijuga (Turp.) Wittrock
Tap water; December; rare.

S. brasiliensis Bohlin
Old reservoir, Sinclair's pond; September to May; fairly common.

S. quadricauda (Turp.) Bréb.
In most collections of desmids, almost pure in fish aquarium; September to July; common.

S. serratus (Corda) Bohlin
Old reservoir; October to December; rare.

Schizochlamys delicatula West
Swamp on Scottsville road; April; rare.

Schizomeris Leibleinii Kuetz.
Stream crossing Fry Spring road, Rivanna River near Milton; October; rare.

Selenastrum gracile Reinsch
Growing in an old aquarium; September; rare.

Sorastrum bidentatum Reinsch
In Davis Pond; September; rare.

Sphaerella lacustris Hazen
Fry Spring; throughout the year; common.

Spirogyra spp.
At least a dozen species of *Spirogyra* have been found ranging in diameter from 7 microns to 145 microns. They are very abundant, occurring in all of the small streams and ponds. Only two instances of conjugation have been observed in a search of seven years. Collections were made during every month of the year.

S. inflata (Vauch.) Kütz
Pond by Lynchburg road; May; rare in fruit.

Spirogyra longata (Vauch.) Kuetz.
Swamp by Garth road; July; rare.

Stichococcus bacillaris Naegeli
In hydrant north of the Randall Building; October; rare.

S. fluitans Gay
In stream by abandoned rock quarry; March; fairly common.

Stigeoclonium lubricum (Dillw.) Kuetz.
Still House Mountain stream; May; rare.

S. nanum (Dillw.) Kuetz.
Small stream emptying into Rivanna River above Free Bridge; April; rare.

S. stagnatile (Hazen) Collins
In temporary spring north of golf links, growing attached to washed out roots; also floating in old reservoir. Collins records this species occurring floating but has no record of its growing attached. November; rare.

S. subsecundum Kuetz.
Growing on small stones in the creek back of the old amphitheatre; September; rare.

S. variabile Naegeli var. *Fritschianum.*
In spring above Southern freight yards; March; very abundant.

S. variabile Naegeli var. *Gayanum.*
In spring above Southern freight yards; March; very common. This variety was mixed with the preceding one. They may be forms of the same variety.

Tetraspora lubrica (Roth) Agardh
In small spring on barbecue grounds, in streams; May; common.

Trentepohlia sp.
On cliff above Rivanna and Moorman's Rivers; all seasons; locally abundant.

Ulothrix variabilis Kuetz.
Stream by golf links; September to June; common.

Vaucheria geminata (Vauch.) De Candolle
Stream by golf links; on moist soil; spring and fall; common.
V. orthocarpa Reinsch
Stream by rock quarry; July; rare.
V. repens Hassall
Growing in well shaded swamp up stream from abandoned rock quarry; April; very common.
V. sessilis (Vauch.) De Candolle
Stream by golf links; spring; common.
Zoochlorella conductrix Brandt
Found in cells of *Hydra*; common at all seasons.
Z. parasitica Brandt
In *Spongilla* and various protozoa; common at all seasons.
Zygnema insigne (Hass.) Kuetz
In most of the small streams; the year round; very common. Several other species have been found but could not be identified for lack of zygospores.

Desmidiaceae

Arthrodesmus triangularis Lagerh. forma *triquetra* W. and G. S. West
In small swamp by stream leading from city reservoir; November; rare.
Closterium abruptum West
Hog wallow on Duke farm; March; common.
C. acerosum (Schrank) Ehrenberg
Swamp in abandoned rock quarry; October; common.
C. acerosum var. *elongatum* Bréb.
Swamp in abandoned rock quarry; October; common. Some specimens as long as 850 μ.
C. Cornu Ehrenberg
Tap water; September; rare.
C. decorum Bréb.
Swamp north of golf links; late autumn; common.
C. didymotocum Corda.
Old reservoir, Chamberlain's pond, Sinclair's pond; September to May; common.
C. fulvum sp. nov.
Old reservoir; September to December; common (see p. 222).
C. gracile Bréb.
Swamp north of golf links; early spring; common.
C. intermedium Ralfs
Swamp in orchard below University cemetery, old reservoir; fall and early spring; common. Some specimens were found which were 600 μ long.
C. lanceolatum Kuetz.
Pool in sunken garden; November; rare.
C. Leibleinii Kuetz.
University ice pond; February; rare.
C. lineatum Ehrenberg
Swamp north of golf links; September to March; common. This species varies greatly in length, being from 290–870 μ long.

C. Lunula (Müll.) Nitzsch
Swamp in abandoned rock quarry; October; common.
C. Lunula var. *intermedium* Gutw.
Swamp in abandoned rock quarry; November; rare.
C. moniliferum (Bory) Ehrenberg
In pond below cemetery; November; common.
C. parvulum Naegeli
University ice pond; March; rare.
C. Ralfsii Bréb. var. *hybridum* Rabenh.
Swamp in upper end of ice pond; March; common.
C. ranunculi sp. nov.
Old reservoir; September to December; common (see p. 222).
C. striolatum Ehrenberg
Davis Pond; October; rare.
C. subulatum (Kuetz.) Bréb. var.
Our specimens differ from the described species in number of pyrenoids and also in general shape. Both margins of the specimens are slightly tumid and not curved as described. Many of the specimens found here are slightly sigmoid. Old reservoir; autumn collections; fairly common.
C. toxon West
Swamp north of golf links; October; rare.
C. turgidum Ehrenberg
Swamp in abandoned rock quarry; September; common.
C. Venus Kuetz.
Old reservoir; fall collections; fairly common.
Cosmarium angulosum Bréb.
Swamp in orchard below University cemetery; November; common.
C. alpestre Roy and Biss.
This species has been recorded from only two other places; by Roy and Bissett from Scotland and by Brown from Lake Ronkonkoma, New York. West states he has never found it. Our specimens are slightly smaller than those described by Roy and Bissett.
C. caelatum (Ralfs) var. *spectabile* (De Not.) Nordst.
Swamp north of golf links; March; fairly common.
C. circulare (Reinsch) forma *minor* West
Swamp in abandoned rock quarry; September; rare.
C. connatum Bréb.
Swamp in abandoned rock quarry; September to December; common.
C. contractum (Kirch.) var. *ellipsoideum* (Elfr.) West
Swamp in abandoned rock quarry; September; rare. This form is a trifle smaller than the measurements given by West, being 26 μ long by 20 μ wide.
C. cyclicum Lund.
Spring up stream from Southern freight yards; May; rare.
C. cylindricum Ralfs
Swamp in abandoned rock quarry; October to February; common.
C. dentatum Wolle
University ice pond; February to April; common.
C. exiguum Arch. var. *subrectangulum* West
University ice pond; March; rare.

C. globosum (Bulnh.) forma *minor* Boldt
Swamp in abandoned rock quarry; November; rare.
C. granatum Bréb.
Swamp in abandoned rock quarry; October to December; common.
C. Hammeri Reinsch. var. *homalodermum* (Nordst.) West
Swamp north of golf links; November; common.
C. Hammeri var. *protuberans* W. and G. S. West
Swamp in abandoned rock quarry; November; common.
C. Holmiense Lund.
Swamp up stream from Southern freight yards; May; rare.
C. isthmium (West) var. *hibernicae* West
Swamp in orchard below cemetery; October to December; common.
C. jenisejense Boldt
Swamp on Still House Mountain stream; March; rare.
C. Lundelli Delp. var. *ellipticum* West
Old reservoir; September to December; rare.
C. margaritatum (Lund). Roy and Biss.
Swamp north of golf links; April; rare.
C. Meneghinii Bréb. forma *latiuscula* Jacobs
Swamp on Scottsville road two miles south of Charlottesville; November to March; common.
C. microsphinctum Nordst.
Swamp north of golf links; November; rare. The specimens were a little larger than the type measurements given by West, being 50 μ by 22 μ.
C. microsphinctum var. *parvula* Wille
Tap water; October; rare.
C. moniliforme (Turp.) Ralfs
Tap water; September; rare.
C. moniliforme var. *panduriformis* Heimerl.
Old reservoir; October; rather rare.
C. Naegelianum Bréb.
Swamp in abandoned rock quarry; October; rare.
C. nitidulum De Not.
Swamp north of golf links; September; rare.
C. obtusatum Schmidle
In ditch beside Scottsville road; May; rare.
C. ovale Ralfs
Swamp north of golf links; year round; very common.
C. pachydermum Lund.
Marsh east of University ice pond; December; rare.
C. Portianum Arch.
Swamp in abandoned rock quarry; October to December; common.
C. sexangulare Lund.
Old reservoir; September to November; rare.
C. subcucumis Schmidle
Pool by golf links; September to May; common.
C. subundulatum Wille
Swamp south of road to city reservoir; April; rare.

C. tetragonum (Naeg.) Arch.
Swamp on Scottsville road, two miles south of Charlottesville; April; rare.

C. Turpinii Bréb.
Swamp in abandoned rock quarry; October to December; common.

C. viride (Corda) Josh.
Swamp near old Fair Grounds; March; rare.

C. undulatum Corda var. *minutum* Wittrock
Swamp north of golf links; February; rare.

Desmidium Aptogonum Bréb.
All along stream by golf links; the entire year; very abundant.

D. Baileyii (Ralfs) De Bary
Sinclair's pond, Chamberlain's pond, old reservoir; the entire year; abundant.

D. cylindricum Grev.
Swamp by Garth road; March; abundant.

D. Swartzii Ag.
Old reservoir; April to October; common.

Euastrum ampullaceum Ralfs
Swamp north of golf links; year round; common.

E. ansatum (Ralfs) var. *pyxidatum* Delp.
Swamp south of road to city reservoir; March; rare.

E. bidentatum Naeg.
Ditch beside Scottsville road two miles south of Charlottesville; April; rare.

E. crassum (Bréb.) Kuetz.
Along stream from old reservoir; at all seasons; very common.

E. denticulatum (Kirch.) Gay
Marsh east of University ice pond; March; rare.

E. Didelta (Turp.) Ralfs
In most swamps; September to June; very common. The form found here is sometimes a trifle smaller than the type, measuring 110–140μ long by 60–70μ wide.

E. dubium Naeg. var. *anglicanum* (Turn.) West
Swamp in abandoned rock quarry; November; rare.

E. gemmatum Bréb.
Ditch on side of the Scottsville road; May; rare.

E. insulare (Wittrock) Roy
Swamp in abandoned rock quarry; September; rare.

E. oblongum (Grev.) Ralfs
Swamp in orchard below University cemetery; at all seasons; very common.

E. verrucosum Ehrenberg var. *alatum* Wolle
Swamp in abandoned rock quarry; at all seasons; common.

Gonatozygon Brebissonii De Bary var. *laeve* (Hilse) W. and G. S. West
Stream by golf links; November; rare.

Hyalotheca dissiliens (Smith) Bréb.
In swamp north of golf links; at all seasons; very abundant.

Mesotaenium De Greyi Turn.
Small stream from Kearney's Mountain; March; fairly common.

Micrasterias americana (Ehrenberg) Ralfs
Marsh east of University ice pond; September to May; common.

M. americana var. *Boldtii* Gutw.
Tap water; October; rare.
M. americana var. *Lewisiana* West
Swamp on Scottsville road; October; rare.
M. Crux-Melitensis (Ehrenberg) Hass.
Swamp east of University ice pond; September to May; common.
M. denticulata (Bréb.) var. *angulosa* (Hantzsch.) West
In swamp north of golf links; at all seasons; common.
M. Jenneri Ralfs
In swamp north of golf links; at all seasons; common.
M. laticeps Nordst.
Tap water; throughout the year; common.
M. papillifera Bréb.
In swamp in abandoned rock quarry; September to June; common.
M. papillifera var. *glabra* Nordst.
Swamp on Scottsville road; May; rare.
M. pinnatifida (Kuetz.) Ralfs
In swamp in abandoned rock quarry; October to December; common.
M. radiata Hass.
In swamp east of University ice pond; March to May; common.
M. rotata (Grev.) Ralfs
In swamp north of golf links; at all seasons; common.
M. truncata (Corda) Bréb.
In swamps in orchard below cemetery; November to June; common.
Netrium digitus (Ehrenberg) Itzigs. and Rothe
Found in all collections of desmids; at all seasons; very common.
N. digitus var. *constrictum* West
Old reservoir; fall collections; rare.
Penium Cylindrus (Ehrenberg) Bréb.
Small swamp on stream by Fry Spring road; February; rare.
P. Libellula (Focke) Nordst. [*Closterium Libellula* Focke]
Pool below cemetery; at all seasons; common.
P. Libellula var. *interruptum* West
Stream crossing Fry Spring road; April; common.
P. margaritaceum (Ehrenberg) Bréb.
Swamp in abandoned rock quarry; at all seasons; very common.
P. Navicula Bréb.
Old reservoir; fall collections; fairly common.
P. spinospermum Josh.
Swamp in orchard below University cemetery; November; rare.
Pleurotaenium coronatum (Bréb.) Rabenh.
Rock quarry; October; rare.
P. Trabecula (Ehrenberg) Naeg.
Swamp in abandoned rock quarry; at all seasons; very common.
Sphaerozosma Aubertianum West var. *Archeri* (Gutw.) W. and G. S. West
Small swamp on Still House Mountain stream; January; rare.
Spirotaenia bispiralis West
Swamp in abandoned rock quarry; September; rare.

S. condensata Bréb.
Swamp in abandoned rock quarry; September to December; common.
S. obscura Ralfs
Swamp on stream crossing Fry Spring road; September to May; common.
Staurastrum alternans Bréb.
Swamp north of golf links; March; rare.
S. alternans var. *pulchrum* Wille
Ditch on side of Scottsville road; April; rare.
S. Arctiscon (Ehrenberg) Lund.
Tap water; September; rare.
S. crenulatum (Naeg.) Delp.
Swamp north of golf links; February; rare.
S. cyrtocerum Bréb.
Swamp in abandoned rock quarry; at all seasons; common.
S. dejectum Bréb.
Marsh east of University ice pond; May; rare.
S. echinatum Bréb.
Temporary swamp below rock quarry; February; rare.
S. furcigerum Bréb. var. *eustephana* (Ehrenberg) Nordst.
Swamp in abandoned rock quarry; October to December; common.
S. gracile Ralfs var. *nanum* Wille
Tap water; October to January; fairly common.
S. lanceolatum Arch.
Davis Pond; October; rare.
S. muricatum Bréb.
Stream from Observatory Mountain; November; rare.
S. orbiculare Ralfs var *depressum* Roy & Biss.
Swamp in abandoned rock quarry; October; rare.
S. orbiculare var. *extensum* Nordst.
Swamp in abandoned rock quarry; October; rare.
S. orbiculare var. *Ralfsii* W. and G. S. West
Swamp in east end of University ice pond; March; rare.
S. paradoxum Meyen
Tap water; September to January; common.
S. Saxonicum Bulnh.
Swamp on Scottsville road; April, rare.
S. sexangulare (Bulnh.) Lund.
Swamp in abandoned rock quarry; October; rare.
S. spongiosum Bréb.
Stream from Observatory Mountain; November; rare.
S. spongiosum var. *Griffithsianum* (Naeg.) Lagerh.
Swamp in orchard below cemetery; November; rare.
S. hexacerum (Ehrenberg) Wittrock
Swamp in orchard below University cemetery; December; rare.
Tetmemorus granulatus (Bréb.) Ralfs
Swamp north of golf links; February; rare.
Xanthidium antilopaeum (Bréb.) Kuetz.
Swamp on Scottsville road; March; rare.

Heterokontae

Botrydium granulatum (L.) Grev.
On mud bank of the Rivanna River above the woolen mills; September to December; common.

Botryococcus Braunii Kuetz.
Filtered from tap water; September to May; common.

Ophiocytium gracilipes (A.Br.) Rabenhorst
Growing attached to some old *Oedogonium* from stream from Still House Mountain; March; rare.

Tribonema bombycinum Derbes & Solier
Swamp north of golf links; November to March; common.

T. minus G. S. West
On backwater of Rivanna River above Free Bridge; November to April; very common.

Rhodophyceae

Batrachospermum moniliforme Roth
In nearly all the small streams about the University; February to April; very common.

Lemanea sp.
In the rapids of the outlet stream of the city reservoir; March; very rare. Observed once, not in identifiable condition.

NEW SPECIES

Anabaena irregularis sp. nov. Plate 16. Figs. 8, 9, 10.

Filaments pale blue-green, separate, free-floating, sheaths often not present; trichomes straight or slightly curved, 3–6 μ in diameter; cells different in shape, some cylindrical scarcely constricted at the joints, 3 μ in diameter, 5–9 μ long; others barrel-shaped or oblate spheroidal, 6 μ in diameter, 4–5 μ long; heterocysts spherical or slightly oblong, 4–7 μ in diameter, 7 μ long; gonidia single, remote from heterocysts, cylindrical, 9–12 μ wide, 12–20 μ long; wall of gonidium smooth.

From water oozing through the brick dam of the old University reservoir.

Lyngbya gigantea sp. nov. Plate 16. Fig. 7.

Filaments solitary and scattered; sheaths close, colorless, smooth throughout, 1–5 μ thick; trichomes 48–60 μ wide, straight, not constricted at the joints; apex of trichomes not tapering; apical cell rotund; calyptra none; cells 6–8 μ long, transverse walls not granulated; cell contents finely granular; pale olive to brown.

In swamp by Garth road, March.

Closterium fulvum sp. nov. Plate 16. Figs. 4, 5, 6.

Cells long, 12–26 times diameter, outer margin 20–25° of arc, inner margin straight or more often concave, not tumid; gradually attenuated toward the slightly recurved truncate invaginate apices; cell wall finely striated, 48–64 striae visible across the cell, striae composed of fine puncta, yellow to reddish-brown; chloroplast usually obscurely ridged, pyrenoids numerous; terminal vacuoles with several to many granules. Length 864–1200 μ, breadth 44–86 μ, breadth of apices 16–19 μ. Zygospore unknown.

Found in tadpoles from the old reservoir, September–December 1930, collected free-floating 1931. Probably at all seasons

In many respects this species resembles *C. pritchardianum*, but is much longer and narrower. The punctate striae always continue to the apex where they converge. The puncta are more distinct in the apex, which is usually darker, resembling in this respect *C didymotocum*. An invagination or indentation of the apex is always present.

Closterium ranunculi sp. nov. Plate 16. Figs. 1, 2, 3.

Cells long, 25–40 times diameter, moderately curved; median portion fairly straight and cylindrical, attenuated toward somewhat incurved apices, which are obliquely truncate and invaginate; cell wall striate, 6–18 striae visible across the cell, numerous puncta between the striae, striae unbroken lines except near apex, where they are resolved into puncta, yellowish to reddish brown; about 30 pyrenoids in each semicell; terminal vacuole with several granules. Length 885–1200 μ; breadth 22–36 μ. Zygospore unknown.

Found in tadpoles and free floating in old reservoir, September–May.

This species is longer and narrower than *C. fulvum*, straighter and incurved at the apices. The unbroken striae are much coarser and fewer in number, and between them lie numerous puncta irregularly arranged. The ends of *C. ranunculi* are not darkened.

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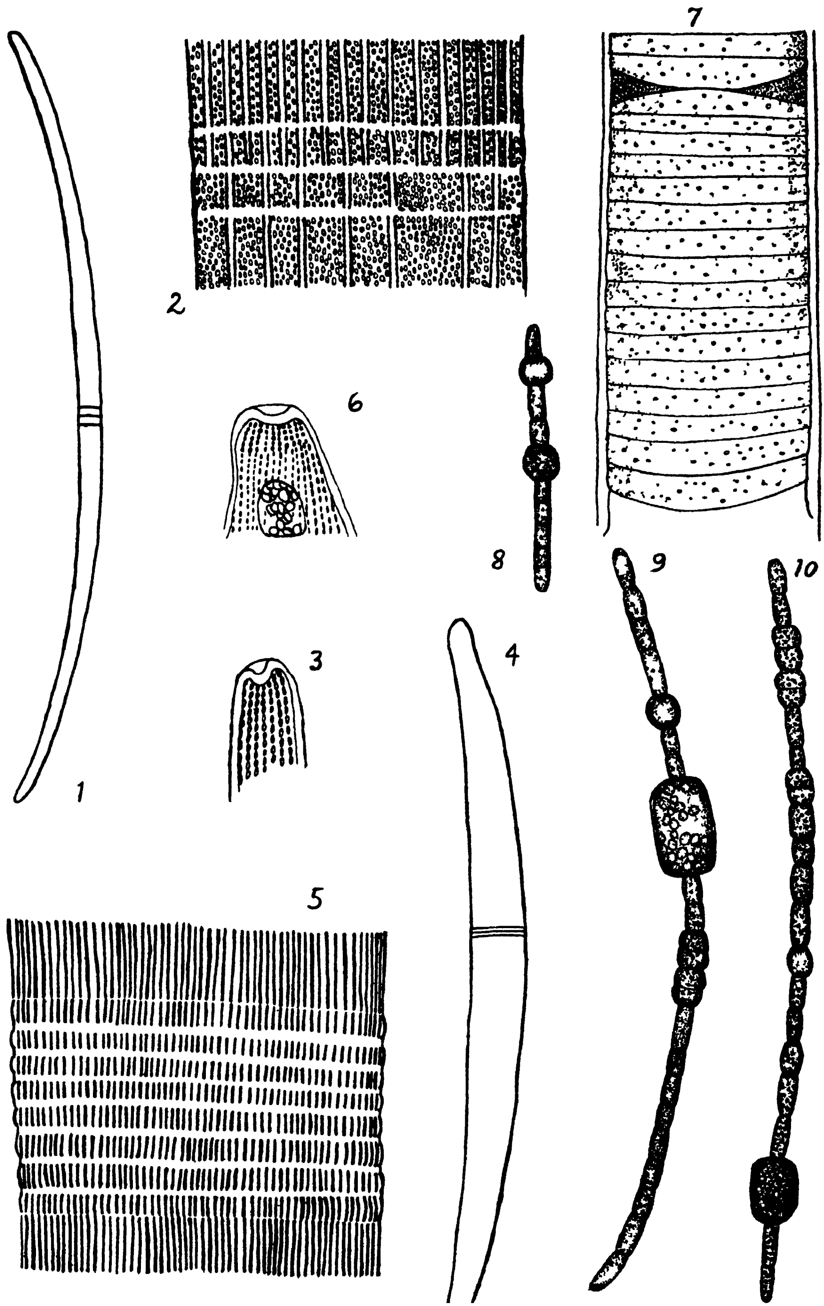
EXPLANATION OF PLATE 16

Fig. 1. General outline of *Closterium ranunculi*. ×142.
Fig. 2. Girdle view of *C. ranunculi*. ×1867.
Fig. 3. Apex of *C. ranunculi*. ×934.
Fig. 4. General outline of *C. fulvum*. ×150.
Fig. 5. Girdle view of *C. fulvum*. ×934.
Fig. 6. Apex of *C. fulvum*. ×142.
Fig. 7. *Lyngbya gigantea*. ×660.
Fig 8, 9, 10. *Anabaena irregularis*. ×934

PLATE 16



THE INGESTION OF LARGE AMEBAE BY THE CILIATE FRONTONIA LEUCAS

By C. Dale Beers

Plate 17

As is well known, the holotrichous ciliate *Frontonia leucas* feeds primarily on algae. Desmids, diatoms, and filamentous blue-green forms are its principal articles of food, though the ingestion of bacterial zoogloea, débris, euglenas, and other small, slowly moving protozoa is not uncommon. Astonishing distortions of the cell-body may result from the ingestion of large desmids (e g., *Closterium*) and relatively long algal filaments.

The process by which desmids, filamentous algae, and the like are ingested has been studied in considerable detail by Goldsmith (1922), who cites five factors as being involved in the mechanics of ingestion. Three of these concern ciliary action: (1) A pull exerted on the incoming food by the circumoral cilia, (2) movement of the ciliate in the direction of the food through the action of its own body cilia, and (3) a series of orderly changes in the position of the *Frontonia* with reference to the food which permit the food to pass posteriorly with greater facility along the aboral (dorsal) wall of the ciliate. The two remaining factors involve physical changes in the cytoplasm: (4) Superficial contractions of the aboral surface of the ciliate which relieve undue local pressure of the food against the pellicle, and (5) cyclosis, which aids in moving the ingested end of the desmid or filament posteriorly.

The present paper adds another form, *Amoeba proteus*, to the list of food organisms given by Goldsmith and presents an account of the conditions necessary for the successful ingestion of food of this type.

A specimen of *Frontonia* which contained a remarkably large, hyaline vacuole was noted in a laboratory culture. In an attempt to ascertain the character of the vacuolar contents, the ciliate was transferred to a slide and gently crushed by the surface film. The ensuing disintegration of the cell disclosed an ingested ameba, which, upon being thus freed, moved away normally. Obviously digestion had not proceeded far. Further examination of the culture revealed other specimens of

Frontonia which contained similar large, clear food vacuoles. In order to observe the process of ingestion, a number of frontoniae were removed to spring water and deprived of food for a day. They were then transferred to culture slides, the depressions of which contained numbers of large specimens of *Amoeba proteus*. Under these conditions all stages in the process of ingestion were observed with but little difficulty, for the frontoniae attacked the amebae without delay.

Most of the attempts at ingestion resulted in failure. The outcome depended both on the size and on the configuration of the amebae. The ingestion of amebae which were creeping close to the substratum and which had a palmate form was never observed. Frontoniae approached such amebae and moved about over them characteristically, as though endeavoring to ascertain their nature, but no observable attempts at ingestion were made. The failure to engulf such amebae was evidently due to the inability of the ciliates to seize a projecting pseudopod.

Furthermore, the ingestion of amebae which were closely adherent to the substratum and moving in a monopodal condition or with only a few free pseudopods was never observed. The ends of the free pseudopods of such amebae were frequently engulfed momentarily, but when the process of ingestion had proceeded as far as the stage indicated in figure 1, the *Frontonia* withdrew, its attempts frustrated by the shape of the ameba. Similarly, attempts to ingest unattached amebae of the shape indicated in figure 1 or of a stellate shape were unsuccessful without exception.

The ingestion of large amebae was therefore confined primarily to monopodal individuals which were unattached, or to unattached individuals which departed from the monopodal condition in having only a few short lateral pseudopods. In rare instances attached amebae which were essentially monopodal and which were executing "walking movements" on the ends of their pseudopods in the manner described by Dellinger (1906) were ingested, but the shape of these usually offered difficulty, even though a *Frontonia* succeeded in detaching them.

Successive stages in the ingestion of a monopodal ameba are shown in figures 2–6. In the process of ingestion the *Frontonia*, after what appears to be a preliminary examination of the entire surface of the ameba, pushes its mouth over one end of the prey (fig. 2). This stage appears to be arrived at, as Goldsmith has pointed out, through the action of the body cilia which tend to push the *Frontonia* toward the ameba, and through the action of the oral cilia which tend to pull the

ameba inward. The mouth of the ciliate then moves along the ameba, until the ingested end of the latter protrudes the aboral wall of the *Frontonia* (fig. 3). Such an area of contact on the aboral surface is designated by Goldsmith as a "tension point." Thus far two of the ciliary factors (action of body cilia and circumoral cilia) have been active. At this stage the three remaining factors become operative. Certain characteristic contractions of the cytoplasm of the aboral region of the ciliate, together with the process of cyclosis, now move the ingested end of the ameba posteriorly (fig. 4), thus relieving the tension point (T) indicated in figure 3. By this means the longitudinal axis of the ciliate comes to lie more nearly parallel to the corresponding axis of the ameba. No doubt the body cilia aid in effecting this change of position. The mouth of the *Frontonia* now moves slowly in the direction of the free end of the ameba (fig. 4), and at length the ameba is completely ingested (fig. 5). Within half an hour the immense food vacuole thus formed has assumed a spherical shape (fig. 6), and the process of digestion is well under way.

The process just described was observed in numbers of instances, though by no means all attempts to ingest unattached, monopodal amebae were successful. In many cases the amebae were much too long to be ingested. In such cases the ingested end was ejected, either gradually or suddenly, when a stage similar to that of figure 3 was attained. Again, short lateral pseudopods offered difficulty, though in some cases the *Frontonia* succeeded in stretching its mouth over these. The ingestion of amebae which were fully one and a half times as long as the frontoniae was observed on several occasions.

The factors cited by Goldsmith appear to be entirely adequate to explain the mechanics of the ingestion process in *Frontonia*, and it can not be denied that these factors are constantly operative and that they are of great importance. Nevertheless, this does not imply that they are the only factors which are involved. Whether solation and gelation phenomena, such as accompany locomotion, movement, and ingestion in *Amoeba* (Mast, 1926), play a part in the ingestion process in *Frontonia* remains to be ascertained. It is entirely possible that such phenomena play a greater rôle than has been suspected, particularly when certain of the more remarkable feeding activities of *Amoeba* are considered. For example, *Amoeba* by means of the pressure of two apposed pseudopodal tips can cleave a *Paramecium* in half (Mast and Root, 1916), or by pseudopodal action it can stretch a *Paramecium* to nearly twice its normal length (Kepner and Whitlock, 1921) or actually stretch a

Frontonia in two (Beers, 1924). These are activities in which cilia play no part; they are the result of gelation, solation, contraction, and streaming of the cytoplasm. Further study may show these factors to be of great importance in the ingestion process in *Frontonia*. To illustrate, may not the mouth of the *Frontonia* at the stage indicated in figure 3 move toward the free end of the ameba as a result of solation and streaming at "A," accompanied by gelation and contraction in the region "B" around the engulfed half, the latter processes serving to hold in place the engulfed half? Such observations as I have had opportunity to make have been inconclusive, and the matter is mentioned merely as one worthy of further investigation.

SUMMARY

The ciliate *Frontonia leucas*, in addition to feeding on unicellular and filamentous algae, euglenas, and various kinds of débris, also feeds on large amebae.

Attached amebae and stellate or irregularly shaped unattached amebae are not as a rule ingested. Ingestion is therefore confined largely to unattached amebae which are essentially monopodal.

The factors involved in the ingestion of large amebae are not unlike those cited by Goldsmith (1922) as operative in the ingestion of desmids and algal filaments. They include the action of the body cilia and circumoral cilia, cyclosis, and characteristic contractions of the cell-body of the *Frontonia*.

The suggestion is made that phenomena of solation, gelation, and cytoplasmic contraction may be of greater importance in the mechanics of the ingestion process than has been formerly believed.

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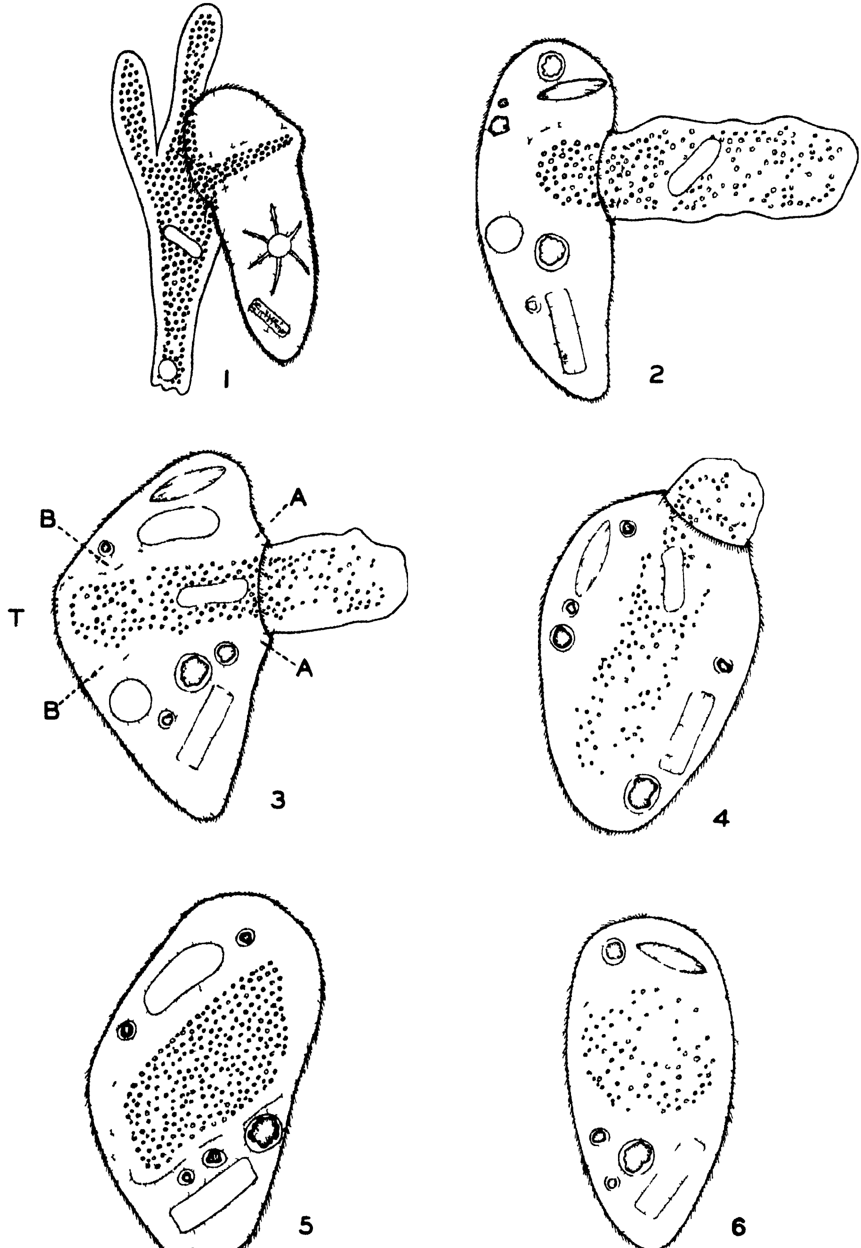
PLATE 17



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EXPLANATION OF PLATE 17

Fig. 1. *Frontonia leucas* attempting to ingest a large, attached specimen of *Amoeba proteus*. The shape of the ameba and its adherence to the substratum make ingestion impossible.

Fig. 2. Early stage in the ingestion of an unattached, monopodal ameba by a specimen of *Frontonia leucas*. The body cilia of the *Frontonia* tend to push the mouth over the ameba; the circumoral cilia aid in pulling the ameba inward.

Fig. 3. Continued ingestion of the ameba, resulting in the production of an area of tension (T) on the dorsal surface of the ciliate.

Fig. 4. Further stage in the process of ingestion. Two factors, cyclosis and certain characteristic contractions of the cytoplasm of the aboral region, move the ingested end of the ameba posteriorly, thus relieving the area of tension; the body cilia aid in bringing the longitudinal axis of the *Frontonia* parallel to the corresponding axis of the ameba, thus permitting the ingested end to pass posteriorly with less difficulty.

Fig. 5. Completion of the ingestion process, with marked distortion of the ciliate.

Fig. 6. Characteristic, hyaline food vacuole resulting from the ingestion of a large ameba.

A TREE-FROG NEW TO THE ATLANTIC COASTAL PLAIN

By Francis Harper

Plate 18

About 8.30 p.m. on April 25, 1932, while crossing the Ogeechee River swamp along U. S. Route 1, a couple of miles south of Louisville, Jefferson County, Georgia, I began to hear a larger chorus of amphibians than had come to my attention during several preceding weeks in the drought-stricken Okefinokee Swamp region. Rain was probably impending here, for it fell before daybreak in Columbia County, a little farther north. The chorus included the Southern Toad (*Bufo terrestris*), the Cricket Frog (*Acris gryllus*), the Green Tree-frog (*Hyla cinerea*), the Common Tree-toad (*Hyla versicolor*), the Common Bullfrog (*Rana catesbeiana*), and—most noticeable of all—some species whose birdlike voice I was at a loss to identify.

From the margin of the flooded river swamp, at the foot of the steep road embankment, I was able to hear perhaps a dozen of the unfamiliar vocalists within a short distance. Most of them seemed to be located a rod or two out from the shore, on trees, logs, or brush. After considerable search I found a couple of fallen trees projecting above the water, and on these I made my way out toward one of the voices. Presently I located with my flashlight a grayish little tree-frog clinging upright to the trunk of a small tree at a height of about a yard above the water. I waited long enough to see it call, in order to verify the authorship of the strange notes, and then captured it.

The call, as heard from this individual and its unseen fellows, consisted of a moderately rapid series of about 20 high-pitched, birdlike notes: *wit, wit, wit,* etc. The notes were delivered just a bit too slowly, however, to constitute an actual trill, such as was being uttered by near-by individuals of *Hyla versicolor.* They were also given at a much slower rate than the rolling notes of the Red-bellied Woodpecker, to which Viosca (1923, 1928) likens the voice of *Hyla avivoca.* The call lasted for a period of several seconds—much longer than that of *Hyla versicolor*—and the rate and pitch seemed to be practically uniform throughout. The alternate inflation and deflation of the vocal sac

during the call was fairly pronounced; yet the intervals between notes were so extremely brief that the degree of deflation probably did not amount to as much as 50 per cent. My observation of the single individual was too hasty to admit of a more precise statement.

A few minutes previously I had passed by a mated pair of tree-frogs, perched on a tree trunk at about the same height as the calling male. I had taken them to be merely *Hyla versicolor*, but now gathered them in on the way back to the road and presently had all three frogs stowed in a vasculum for safe keeping overnight. I anticipated no difficulty the following morning in distinguishing the single strange male from the pair of supposed *Hyla versicolor*. When examined by daylight, however, all three frogs were most obviously of the same species! Meanwhile some eggs had been deposited in the vasculum.

Examination of a series of *Hyla avivoca* in the U. S. National Museum a few days later, and a careful comparison of my Ogeechee River specimens with the original description and figures by Viosca (1928), left no doubt that these specimens represented *avivoca*, thus constituting the first record for the species in Georgia and on the Atlantic coastal plain.

The two males exhibit no noteworthy differences from Viosca's description. The measurements (in millimeters) of the two males and the female are, respectively, as follows: total length (snout to vent), 36, 35.5, 49; length of head (including tympanum), 11.5, 11, 15; width of head at posterior border of tympana, 12.5, 12.5, 18; length of arm from axilla, 22.5, 23, 33; length of leg from groin, 52.5, 52.5, 73; tibia, 17, 17, 23.5; heel to tip of fourth toe, 24, 24, 33. In coloration the female closely resembles the males, but its throat, instead of being 'peppered with dark,' is only lightly spotted. The sexual difference in size (assuming that the single female is of average proportions) is far greater than that recorded for *Hyla versicolor* (cf. Dickerson, 1906, p. 119, and Wright, 1931, p. 329). In fact, no equal discrepancy in the size of the sexes seems to be recorded for any of the other Hylidae of eastern North America. Viosca remarks (1928, p. 89) that the females of *Hyla avivoca* are larger than the males, but gives no measurements of the former. This species bears such a remarkable resemblance to *Hyla versicolor*, both in general appearance and in the details of its color pattern, that scarcely any one would detect the difference except by critical examination, or by hearing the voice.

An interesting reptilian associate of this tree-frog in the Ogeechee River swamp is the Copperbelly (*Natrix sipedon erythrogaster*), of which there do not appear to be many Georgia records. I found a

large dead specimen on the roadway at this point, and I also saw a large live individual, probably of the same species, in the edge of the swamp. The latter was uniformly colored above, but I did not ascertain its ventral coloration.

On the afternoon of the same day (April 25) I had stopped at the Ohoopee River swamp about 4 miles north of Oak Park, in Emanuel County, Georgia. Here I had heard some unfamiliar birdlike notes (which I suspected to belong to an amphibian), and in endeavoring to trace them to their source, I detected a *Hyla* about 8 feet up in a young cypress. I made a couple of attempts to grasp it, but the creature escaped, first by leaping to another limb, and then apparently to the ground. Its appearance corresponded very closely to that of the Ogeechee River individuals seen a few hours later, and I believe that it, too, was a *Hyla avivoca*. Another amphibian found in the Ohoopee River swamp was an Alligator Frog (*Rana heckscheri*), which I observed at close range in a pool and identified very satisfactorily, though I failed to capture it. This evidently constitutes the northernmost record for the Alligator Frog to date.

In his original description Viosca (1928) recorded *Hyla avivoca* only from Louisiana and Illinois It is probably this same species, however, that was recorded a short time previously (under the name of *Hyla phaeocrypta* Cope) from Tennessee by Dunn (1927) and from Kansas by Burt (1928)—in each case on the basis of a single specimen. The foregoing scattered records suggest that the 'Bird-voiced Tree-frog' has a rather wide distribution in river and creek swamps of the central and lower Mississippi Valley as well as in certain parts of the coastal plain of Georgia (and probably Alabama)

Apparently the only information hitherto available concerning the habits of this species is contained in the two papers by Viosca cited above, and perhaps in one by Ridgway (1924). The latter's notes, however, deal with an unseen and undetermined species, and would seem quite applicable to *Hyla crucifer*.

SWARTHMORE, PA.

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PLATE 18

HYLA AVIVOCA, MALE

From Ogeechee River swamp near Louisville, Ga April 26, 1932 Photographs

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1927. *Hyla phaeocrypta* in Tennessee. Copeia, No. 162, Jan.-March, p. 19.
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1924. Additional notes on *Hyla phaeocrypta* (?). Copeia, No 128, March 31, p. 39
VIOSCA, PERCY, JR.
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WRIGHT, A H.
1931. Life-histories of the frogs of Okefinokee Swamp, Georgia. New York: pp. xv + 497, 46 pl., 1 fig

PHTHIRACARID MITES OF FLORIDA

By Arthur Paul Jacot

Plates 19–22 and 2 Text Figures

INTRODUCTION

Between January 5th and the first of August, 1928, Mr. E. F. Grossman, with the coöperation of other workers of the Agricultural Experiment Station of the state of Florida, secured 126 lots of Acarina. Of at least seventy-five of the lots containing Oribatoids, Phthiracarids occurred in forty-three. The present paper is a report on these Phthiracaridae, kindly sent me for study by Dr. John W. Wilson, who is now in possession of the collection.

Rather than to repeat under each species the data related to each lot, this datum, published in the following paragraph, can be referred to by means of the lot numbers cited under each species. Lots not bearing a collector's name were secured by Mr. Grossman.

6. Leaves from ground about Azalea bushes, shady place, apiary grounds, Gainesville; Jan. 26 (?).

10. Leaves from ground, sunny, rather dry, live oak and pine, very little grass, Perry; Feb. 2.

11. Leaves from ground, sunny road-side, live oak and pine, very little grass, Mayo; Feb. 8.

13. Wet leaves from moist ground, rainy and cloudy all day, horticulture grounds (third row from Japanese plum, 28th and 29th tree from woods), Gainesville; Feb. 13.

21. Palmetto scrubs and scrub oak, North Beach, St. Augustine, Feb. 19.

23. Pine needle litter of 12–16 inch pine trees, not burned off for several years, soil moist, very few scrub oak present, high land two miles west of Madison; Feb. 23.

28. Leaves from base of trees in an abandoned orange grove, five miles beyond Micanopy; Feb. 26.

29. Leaves from under small elders from which 26 collections were made from half to three-quarter inch leaf mulch, rather damp, magnolia, elder, prickly oak and live oak leaves mixed in, horticulture grounds, Gainesville; Feb. 29.

30. One inch leaf mulch, shady spot, quite damp, no elders, horticulture grounds, Gainesville; Feb. 29.

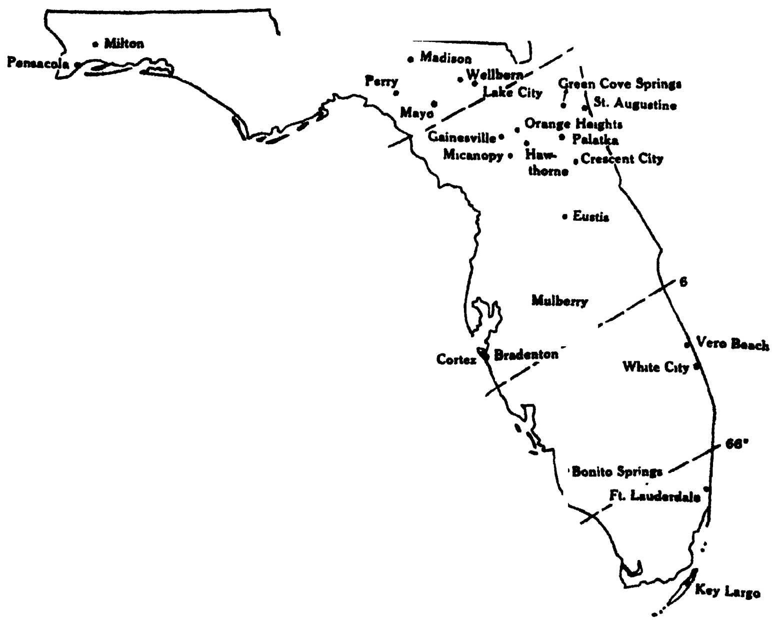
33. Leaves from half inch undisturbed mulch, soil slightly moist, high, dry land under hickory tree, Pinkoson Springs, Gainesville; March 4.

34. Leaves from shore bay under *Tamola littoralis* Small, tree on inner edge of twenty foot sand dune on ocean edge, seven miles from south point on North Beach, St. Augustine; March 7.

35. Sod and litter of colony of sea oats (*Uniola paniculata* L.), south point (ten feet elevation), North Beach, St. Augustine; March 7.

44. Leaves and grass from ground, old Bradenton Laboratory, Bradenton; March 14; coll. by George F. Weber.

45. Cortez; March 15; Weber.



TEXT-FIGURE 1. OUTLINE MAP OF FLORIDA INCLUDING LOCALITIES FOR THE FORTY-THREE LOTS AND THE JANUARY ISOTHERMS

48. Spruce and pine needles and small limbs from ground, burned land, Orange Heights; March 18.

54. Needles from long leaf pine, east shore of Newmans Lake, Gainesville; March 25.

55. Same, from south shore.

61. Litter from second growth pine, east of Oscuala Country Club, five miles west of Pensacola; March 29; coll. by G. H. Blackmon.

62. Pine needles and live oak leaves from level but low land, three miles northwest of Milton; March 29; Blackmon.

63. Litter (?), twelve miles from south point on shore of North Beach, St. Augustine; April 1.

67. Shore bay débris, Vero Beach; April 6; coll. by Erdman West.

69. Live oak leaves, east side of St. John's River, East Palatka; April 15.

74. Leaves from sweet-gum, three miles southwest of Micanopy; April 17.

75. Leaves from ground, horticulture grounds, Gainesville; April 21.

76. Oak leaves, upper edge of Devil's Mill Hopper, Gainesville; April 24.

77. Green moss and damp grass, lower part of Devil's Mill Hopper, Gainesville; April 24.

80. Leaves from oak woods, on state road one mile west of Green Cove Springs; April 29.

81. Damp leaves from edge of water in Devil's Hole, two miles north of Edgar on Hawthorne-Palatka road, about eight miles from Hawthorne; May 1.

82. Leaf litter of live oak, one mile north of Crescent City; May 1.

84. Dry oak leaves, horticulture grounds, Gainesville; April 27; coll. by Homer F. Bratley.

87. Leaf litter, locality of lot 44; May 2; Weber.

90. Dry leaves, near insectary, horticulture grounds, Gainesville; Bratley.

92. Dry leaves, Key Largo; May 10; Weber.

95. Dry leaves, Bonita Springs; May 4; coll. by James R. Watson.

101. Leaves from beneath oak, magnolia and hickory trees, no pine, National Forest, one mile east of Villa Tasso on Choctawhatchee Bay; May 18; coll. by R. W. Blacklock.

103. Leaves beneath water oak tree, one mile east of Mulberry; May 17; coll. by West.

105. Leaves from ground, Eustis; June 20.

108. Elder leaves, White City; May 28; coll. by Watson.

109. True moss, Sugarfoot Hammock, Gainesville; June 10; Watson.

111. Large leaves from wood fern common in Florida, Gainesville; May 28; Bratley.

113. Débris from hammock land; Fort Lauderdale; March 25; coll. by D. M. Bates.

115. Live oak and pine leaves from ground, Wellborn; May 30.

116. Live oak leaves; Gainesville; May 30.

SYSTEMATIC ACCOUNT

In 1923 (14) I recognized three families of Ptyctyma. At the present time I do not regard these groups as sufficiently differentiated to consider them of higher rank than subfamilies. The recent outstanding contribution of Grandjean (9) necessitates changes in the key then published, as follows:

Abdomen covered by telescoping plates, and therefore capable of considerable contraction and expansion . . . . Protoplophorinae

Abdomen covered by a single plate

- Genital and anal openings united . . . . Phthiracarinae
- Genital and anal openings distinct, separate . . . . Mesoplophorinae

Subfamily **Protoplophorinae** (17, p. 210)

Characters: Dorsal area of abdomen covered by at least two notogastral plates, the posterior one (pygidium) capable of telescoping under the anterior one (pronotaspis) and usually found in this position in preserved material; sides covered by freely movable, lateral plates (pleuraspides), as far as now known, one on each side.

Type: Protoplophora (3, p. 217).

Genus **Aedoplophora** (9, pp. 12 and 29)

Characters: Sides of aspis pushed out to form an angular rim which converges rapidly on apical third to form a terminal prow; palps five segmented; the two transverse ridges of pygidium fairly close together; anterior edge of pleuraspides barely or not lobed; anal covers each formed of two fused plates and thus bearing two rows of bristles.

Type: *Aedoplophora glomerata* (9, p. 12, monotypical).

1. **Aedoplophora major** *sp. nov.*

Figures 1–9

Diagnostic characters: Pseudostigmatic organs with a flattened head bearing rows of not particularly short bristles (figures 1, 2, 5); vertical bristles as long as rostral; four median bristles of pronotaspis as long as vertical; each anal cover with three major bristles.

Dimensions (of a medium sized individual):

Length of pronotaspis,	265;	of aspis, 210
Breadth of same,	225;	of aspis, 200

Description: Aspis sanded, except lateral portion; with distinct carina running from tip of rostrum nearly to pseudostigmata. In the one lateral aspect (figure 2) the carina did not show up distinctly but in the two dissections it is very strongly marked. That it is a sharp, distinct angle is evident from figure 4. There also appears to be a slight subsidiary ridge just mediad of the carina (figure 5). Proximal edge of aspis strengthened by a raised, chitinous band. It was impossible to locate definitely one of the pairs of bristles. The rostral bristles were clearly visible. In figure 2 one is shown projecting beyond the carinal bulge because of the angle at which it is seen. The bristles of the other pair are inserted close to the pseudostigmata. The bristle of figure 2

is evidently the same for the further side. There seems to be an insertion distad of the pseudostigmata but I have not been able to discern a bristle. The two exopseudostigmatal bristles are shown in figure 5.

Pronotaspis (figure 2) sanded; with a distinct collar of some breadth (figure 3), terminating in a thickened ridge. The four median bristles (a:1 and a:2) inserted near it. Bristles a:1 as approximate as a:1 is distant from a:2. Bristles a:3 were not discernible but what appears to be an insertion was observed as in figures 2 and 3. Bristles a:4 far posteriad (figures 2 and 4). Pygidium (broken line in figure 2) at least partly sanded; very similar to that of *Aedoplophora glomerata* but peripheral bristles in a straighter row I designate bristles of first transverse ridge as b, those of second ridge as c, and the peripheral as d. Bristles b:1 slightly more approximate than are a:1; b:1 to b:2 equals b:1 to b:1; c:1 still more approximate; c:1 to c:2 equals b:1 to b:1; d:1 slightly more approximate than c:1. In figure 4, I have shown only bristles d:1 of the peripheral row.

Pleuraspides (figure 6, where it is in the same position as in figure 2) sanded, except outer edge which is very thin; with a distinct ridge or apodeme running from end to end. This seems to be the skin fold of Grandjean or at least the point of attachment of the ventral membrane. The central portion of the apodeme is really double and the angle is produced as a keel or lapet (figure 7, stippled area) under which the anal cover is housed or held in place. In figure 2, I distinctly saw a bristle on the anteroventral edge, i.e. opposite the genital aperture (which, in this figure, is indicated by broken lines). This is also shown in figure 4. In figure 6 the two distinct bristle insertions are shown as heavy circles, the lighter ones being uncertain. I have been unable to locate the anterior bristle in the pleuraspides dissected out.

Anal covers together shaped like half a lemon peel, if the lemon is cut from end to end. The terminal nubbins articulate with the posterior corner of the pleuraspides; edges of the covers are somewhat undulate at their posterior end; center of each cover bears a longitudinal ridge on which are inserted three, long, curved bristles (figures 6 and 7). Each cover is produced laterad in the form of an *articular arm*. This arm is at a lower level than the face of the cover (figure 8). The arm is composed of two ribs, one running out from the proximal part of the cover and a longer one running out from the distal corner (figure 7). They meet to form a triangular knob (figure 7) which articulates beneath the flange of the pleuraspal apodeme (figure 7, where the flange is stippled). In figure 6 this arm appears dorsad of the cover, running obliquely to-

ward the apodeme flange. In figure 4 the arms appear as lateral angles to the proximolateral corners of the covers; this is due to their great foreshortening in this aspect. A row of seven to eight, fine bristles are inserted at juncture of anal cover and its arm (figure 7). The skin fold described and figured in that species, very much resembles the outline of the articular arm.

Tarsi I have ciliate, ventral face bristles. The palps (figure 9) bear fairly long, evenly curved, fine bristles.

Type locality: Key Largo; from dry leaves, taken May 10th by G. F. Weber; four specimens; slides G92P1 and P3 to P5.

Subfamily **Phthiracarinae** (17)

I find no *special* reason for studying the mouthparts and the legs of the Phthiracarinae at the *present* time. Trägårdh has figured *mandibles* about twenty-nine times while I have figured them eight times (besides observing them many more times). I do not consider that the *specific* differences in the *mandibles* are of such systematic value as to warrant spending the necessary time to figure or note them. That their study has "philosophic" value, I do not doubt. That is for another generation to determine.

For dimensions the greatest (diagonal) length of notogaster and the greatest height of notogaster (not including nubbins) is used because the total height of the animal varies with degree of retraction of genital and anal covers. For instance when these animals are expanded (extended) the genital and especially the anal covers are drawn well into the body, when the animal is closed up these covers are pushed out to their maximum extent. This is not so true of Steganacarus. Total length of aspis is from proximal end of same as seen through the wall of the notogaster. Unless otherwise specified, dimensions are in microns.

Paragraphs which seem to be copied out of my earlier paper (17) bear corrections or modifications. Grandjean's (9) important contribution on the Protoplophorinae requires reconsideration of certain structures in the Phthiracarinae. According to his studies, the notogaster is made up of four plates which he designates: pronotaspis, pygidium and pleuraspis (a pair). The ventral plate he regards as the ventral portion of the pleuraspides. The dorsal edge of the ventral plate he considers the "dorsoventral line of attachment" of the "ventral membrane." After careful reëxamination of material on hand, I am convinced that this "line," in the Phthiracarinae, is a ridge or apodeme. This apodeme runs along the longitudinal center of the pleuraspides.

Thus the ventral plate would actually extend dorsad of this apodeme. I am, for simplicity, retaining the term ventral plate in this report with the understanding that its dorsal edge is dorsad of the *ventral membrane apodeme*. *Hypochthonius rufulus* clearly shows the pleuraspides.

Another observation is that my VP:1 and VP:2 are the two bristles of the pleuraspides. (I also suspect that the postanal bristles of the Galumnidae are homologous.) A study of the figures of *Ph. setosum*, *Steganacarus diaphanum*, *Steg. thoreaui* (17) will show that VP:3 is above the phragma while VP:1 and 2 are below it. In the Protoplophorinae, I find nothing to correspond with VP:3, unless it be the bristle of figure 2.

Finally the bristles I:1, II:1, III:1 and III:2 are homologous with bristles of the pronotaspis; bristles I:2 and II:2 with those of the first transverse ridge of the pygidium; bristles I:3 and II:3 with those of the second ridge; while I:4, I:5, II:4 and III:3 are homologous with the peripheral bristles. This gives a total of twenty-four notogastral which, with the four VP:1 and VP:2, totals twenty-eight. This leaves VP:3 unaccounted for!

In view of this transverse segmentation and the consequent primitive arrangement of the bristles in transverse rows, the system of enumeration of the bristles which I have been using should be modified to accord with this homology. In the present report I follow the former system, but in a forthcoming paper I will use letters to denote the transverse rows, and numerals to denote sequence from median plane, I:1 becoming a:1, II:1 becoming a:2, I:2 becoming b:1, and so on.

I am of the opinion that further research will show the pygidium of the Protoplophorinae to be made up of more than one segment.

Key to Tribes

Anogenital area about as broad (or broader) than length of any one of the four rectangular plates, and never as long as ventral face of abdomen
Phthiracarini (figures 10–24)

Anogenital area much narrower than length of any one of the two or four strap-like plates; and extending along entire length of abdomen
Euphthiracarini (figures 26–32).

Tribe PHTHIRACARINI (17, p. 214)

Form usually globular, oval or depressed, rarely compressed; chitin usually thin, dark, tending to olivaceous greenish and dark brown as seen in balsam mounts by indirect illumination; sides of aspis occasionally slightly angled, forming the *carina* which limits the lapet when

animal is closed; rib short, not conspicuous; pseudostigmatic organs usually simple, below them and below aspis rim is usually inserted a fine bristle, the *nuchal bristle*; collar rather thin, and not prominent; lapet well developed and prominent; ventral plate complete around the posterior end of the anal covers, not bent inward; anal and genital covers large, more or less quadrangular and contiguous, with central corners usually modified in the form of *nubbins* to interlock, adjacent edges also warped and curved so as to complement, and evidently opening and closing together; an *accessory plate* within anterior edge of genital covers, which normally lies against inturned rim of genital covers but is often retracted so as to be some distance dorsad or drawn into abdominal cavity so as to be invisible from outside. Its distal end is usually visible projecting ventrad of lapet (figure 23). Each side of aspis usually with a recess (appearing as a clear area or spot at anteroventral aspect of aspis, and referred to as *accessory plate notch*) into which the lateral end of this plate fits when aspis is closed (see figure 14). Genital covers each with three series of bristles: an *anterior*, within the anterior rim, usually consisting of three, directed forward and registering approach of aspis, a *marginal*, usually comprising two bristles situated within anterior half of inner margin and directed toward each other and registering closure of covers, and an *outer*, usually of four bristles, situated a short distance from inner edge and registering contact of covers with outside objects; ungues armed with a single, fairly large, often toothed hook.

Key to Genera

1. Anal covers quite flattened, often completely retracted into body cavity, their median edge bearing but two well spaced bristles (figures 10, 12, 14, 16)......2
1. Anal covers strongly convex, thus prominently protruding beyond ventral plate, and bearing at least three closely spaced bristles along median edge (figures 18 and 23)......3
2. Vertical bristles prominent and erect New genus (see below)
2. Vertical bristles invisible or lying close to surface of aspis.....*Phthiracarus*
3. Anal covers with three closely and subequally spaced bristles along median edge......*Hoplophorella*
3. Anal covers with four closely and subequally spaced bristles along median edge......*Steganacarus*

Genus **Hoplophthiracarus** *gen. nov.*

Characters: Phthiracarini similar to species of the genus Phthiracarus but differing in that the vertical bristles are erect and therefore con-

spicuous. Areolation or sculpturing of the surface is also developed in some species. These species I consider more primitive than those of the genus Phthiracarus because the vertical bristles of other Oribatoidea and Acarina are erect, as well as the notogastral bristles. Thus the procumbent bristles of the Phthiracarini are a specialization.

Type: *Hoploderma histricinum* (2, p. 12).

2. **Hoplophthiracarus histricinum** (2, p. 12) comb. nov.

Figures 14, 15

Diagnostic characters: Body rather small (abdomen 0.4 mm. long); oval; greyish green to pale brown or even pale rustaceous brown; notogastral bristles stout, rather straight; aspis flattish with protruding rim; rostral bristles easily seen; pseudostigmatic organs long, slender, angularly curved, slightly thickened at apex; surface of notogaster and dorsal face of aspis with areoles of dots.

Dimensions (of nine measurable specimens):

Length of notogaster,	369(393)411;	of aspis, 205(209)217
Height of same,*	221(235)248;	of aspis, 86 (88) 90
Breadth of same,	246(280)300;	of aspis, 139(155)164

Thus this species is distinctly depressed, so that mounted specimens showing side view are rare (unless broken open). In studying the next species, three much larger specimens were found.

Description: Aspis seen from side (figure 14) flattish, with prominent angle between dorsal and anterior face, roughened by areoles which are visible chiefly on dorsal face, anterior face also flattish; no ridge; a faint carina; accessory plate notch large, similar to that of preceding species; rim distinct, well formed, protruding conspicuously; rib short but stout; vertical bristles the longest of the body, slightly bent near middle; rostral bristles curved, inserted near anterodorsal angle of aspis, twice as approximate as vertical; lateral bristles very small (figure 15), distant from pseudostigmata; lid small, barely covering orifice; pseudostigmatic organs smooth at apex.

Notogaster seen from side (figure 14) with rather low posterior end, highest just anterior to middle, seen from above (figure 15) broadly rounded behind, quite flat in front; surface granular, granules usually aggregated into rough circles giving it a pockmarked appearance.

* Two measurements only.

These circles contain from five to seven such points. In some individuals with evenly granular surface, there is faint pocking on the interior surface of the chitin wall. These pocks when strongly developed are separated by interstices the diameter of which is at least half that of the pocks. This great variation in sculpturing led the Italian acarologist to use a varietal name. All intergrades occur. Collar narrow, undulate; notch very oblique; lapet rather long, strongly tapering; bristles stout, rather straight, sometimes slightly barbed at distal end; I:1–5, II:1–4, III:1–3; I:1 distant from collar, III:1 on longitudinal plane dorsad of pseudostigmata, and therefore higher up than III:2; a pseudofissura (?) anterior to II:3; I:2 much more remote than I:1, I:3 only slightly more approximate than I:2, thus median series are rather widely spaced.

Ventral plate sanded, most restricted at posterior end of genital covers; denticles well developed, slender (figure 15); bristles 1 and 2 inserted in crescentic notches, bristles 3 entirely above ventral plate; accessory plate with rather rounded end (figure 14). Genital covers quite rectangular, with low anterior rim, like the anal plate somewhat sanded-pebbled, sometimes with granular areoles in restricted areas; bristles evident (figure 14), spaced as in figure 15 though the members of a pair are not always opposite; median edge notched near posterior end; posteromedian corner somewhat drawn out. Anal covers with sides well rounded out (figure 15); internal crossbar slender but strongly bent; anteromedian corner strongly drawn out into a rather long nubbin; bristles of median row much shorter than those of lateral row, rather close together; lateral bristles unusually close to median plane, II:2 on transverse plane of I:1, II:3 at least as close to I:2 as I:2 is to I:1.

This species so closely resembles species of Steganacarus that I at first took it for one of them but the anal covers are entirely different. Its type locality is North America! This term may have been used by Berlese for species occurring both in Missouri and Florida. Its author, who described and reported eighty-two species and subspecies from North America, received material from three states: Florida (especially Lake City), Washington, D. C., and Columbia, Mo. The type locality of the subspecies is: "Florida." If the description is meager, the figure and the description of the pseudostigmatic organs leaves no doubt as to its identity. For instance the anal covers are distinctly *not* those of a Steganacarus. The long, nearly straight bristles are distinctive and give the specific name of "little hedgehog." The description states that there is no carina (which I call ridge), thus again it is not a Steganacarus.

The species description calls for "a coat which is lightly rough-punctulate." Then in parentheses, as though unimportant or indistinct, is added: "rounded, widely placed areoles, *between* which the coat is minutely punctulate." In the variety (*P. h. nitidior*) "the coat is not distinctly pock-marked, areoles punctate but nearly smooth, entirely densely punctate; outline of areoles nearly evanescent, difficult to distinguish." As stated above, this distinction is not constant and intergrades are as common as the extremes, though the form with punctate areoles is the most common. The size difference is significant especially when taken with the chestnut (not earthy) color.

Occurrence: Pensacola (one specimen: G61), Perry (one specimen: G10), Gainesville (one specimen: G77), Bradenton (nineteen specimens from two lots: G44, G87). Thus along the west coast but most abundant from leaves about the old Bradenton laboratory.

In the present material, I find a form closely resembling *P. histricinum* but larger and darker, a good brown, but, unlike *P. h. nitidior,* the specimens are coarsely areolated, the interstices forming a conspicuous network. If anything, the pale colored, smaller *P. histricinum,* at least some of the specimens, would be *P. h. nitidior,* i.e., somewhat shining. Thus this larger, rougher, brown form, secured only from the west end of the state, requires designation and may be known as:

3. **Hoplophthiracarus robustior** *sp. nov.*

Figures 16, 17

Diagnostic characters: Deep amber brown; strongly reticulate, elongate; aspis more vaulted, not flattened; rostrum produced well beyond the very slender rim; carina distinct; vertical bristles straight, distal half swollen, rough; pseudostigmatic organs shorter and stouter than in preceding species; bristles of anterior part of notogaster not tapering, all notogastral bristles rough along distal third, ribbed, i.e., square in cross-section, and almost straight except II:1 which is strongly bent posteriad and swollen along distal third.

Dimensions (of four measurable specimens):

Length of notogaster,	435(454)496;	of aspis, 225(241)263
Height of same,	262(290)332;	of aspis, 107(110)115
Breadth of same,	287(295)313;	of aspis, 143(162)168

Thus this species is about as broad as high.

Description: This species is so much like the preceding that a detailed description would be needless repetition. Notogastral bristles I:1 are three times as remote as rostral, I:5 very slightly more remote than I:1, ventral plate bristles 3 are twice as remote as notogastral I:1.

The anal and genital covers are scrolled, i.e., they have no definite pockmarking. The anal covers have the median edge raised as a slight rim or bead. This rim fits into the ventral plate denticle notch which is more of a groove than a notch but appears as a notch when viewed in ventral aspect which is obliquely to the face of that part of the plate. Figure 17 illustrates this groove, the denticles, and the areolations as they appear when viewed at right angles to the plate. Thus these denticles and notch are useful in insuring the proper set of the anal covers and preventing tortion by external agents. The denticles are longer than in *H. histricinum* and the notch shallower, thus making a striking contrast.

Occurrence: The thirteen specimens before me all came from one lot taken five miles west of Pensacola from second growth pine, March 29th (G61).

Intermediates: Three specimens of *H. histricinum* from Bradenton are 450 micra long and therefore as large as average *H. robustior*. In all other characters they are *H. histricinum*. Similarly, one of the specimens of *H. robustior* is only 350 micra long though typical in all other respects. If these two species should be found to have structural characters mixed, it would indicate that *H. robustior* is a subspecies or geographical race of *H. histricinum*.

4. **Hoplophthiracarus grossmani** *sp. nov.*

Figures 12, 13

Diagnostic characters: Body small, depressed, low anteriorly; greyish green; notogastral bristles bent anteriad; aspis with very slight median ridge; no distinct rim; rostral bristles fairly long, straight; pseudostigmatic organs long, stout, curved anteriad and dorsad, so that the pointed distal end reaches nearly opposite dorsal edge of aspis (figure 12).

Dimensions (of two specimens):

Length of notogaster,	304 and	382,	of aspis, 152 and 197
Height of same,	205	—,	of aspis, 61 —
Breadth of same,	—	250,	of aspis, 103 and 150

Description: Aspis (figure 12) not large, blunt, with a slight carina; in lateral profile, highest at insertion of vertical bristles, angled close to transverse plane of pseudostigmata; no thickened rim though edge of aspis flares outward; accessory plate notch small but high; a distinct angle between dorsal and anterior faces; rostral bristles inserted well proximad of this angle, straight, fairly long; lid small; what may be regarded as a slight carina descends from dorsal edge of pseudostigmata towards rib; vertical bristles longest of body, curved posteriad; pseudostigmatic organ is so long and cumbersome as to be broken off short in three out of four (see figure 13).

Notogaster seen from side (figure 12) ovate, largest at posterior third, anterior edge flattened, anterior aperture small, flattish behind; seen from above (figure 13) slightly ovate, broadly rounded behind; collar narrow, angularly curved; lapet prominent; notch deep; bristles well developed, curved anteriad, insertions simple; I:1–5, II:1–4, III:1–2 or 3; I:1 not on collar, I:1 as remote as I:2, I:3 slightly more approximate, I:4 and I:5 still more approximate, III:3 was not discernible in the two specimens at hand.

Ventral plate conspicuously produced mediad anterior to posterior edge of genital covers; denticles rather in the form of a median notch; bristles inserted on edge of plate (figure 13). Genital covers with low, blunt anterior rim; posteromedian corner produced as a tooth to fit into a corresponding notch in the anal covers; bristles not discernible, judging from the two specimens before me, arranged as in figure 13. Anal covers much longer than genital, considerably broader behind than in front (figure 13); bristles well developed, I:1 and I:2 unusually close together, II:2 inserted on transverse plane passing just anterior to I:2.

Closely related to *P. pavidus* of Europe but with a different pseudostigmatic organ. It resembles *H. illinoiensis* but has stouter pseudostigmatic organs, slender, curved notogastral bristles, and the chitin has a sanded surface.

Occurrence: Pinkoson Springs, Gainesville, taken March 4th from half inch of leaf mulch under hickory, high, dry but slightly moist on soil, one specimen: G33; Vero Beach, taken April 6th, from shore bay débris, one specimen: G67.

Genus **Phthiracarus** (21, p. 874)

Characters: Phthiracarini with chitin thin and relatively smooth, when seen under high magnification sanded (irregularly stippled) or

finely, irregularly vermiculate or scrolled; setae usually fine to lacking, those of aspis usually difficult to distinguish, never erect, the median pair low down on sides; aspis without distinct median ridge (carina); rim usually distinct and well formed; lid descending from above backward, free from aspis behind pseudostigmata; bristle insertions most often simple and direct; middle of sides of notogastral plate with an indefinite, darker spot resembling a bristle insertion; ventral plate broad behind anal covers; anal covers not conspicuously convex, the bristles disposed in two rows: a *median* (referred to by Roman numeral I) and a *lateral* (designated by II); the median series usually consisting of three well spaced bristles, the lateral series of two; anterior edge of covers on interior face with a well-developed, posteriorly curved crossbar which throws a dark, shadowy band across covers at this point; genital covers with posteriorly directed lobe which fits under anal covers and into hollow of the anal cover cross-band.

The term Hoploderma (20, p. 77) was instituted to supplant the preoccupied name Hoplophora (19, p. 116) and thus by international rules takes the same type: *H. laevigata* which is synonymous with the type of Phthiracarus (21, p. 874). German acarologists use the term for pitted or rough species with *H. laevigata* (meaning smooth) as type!

5. **Phthiracarus sphaerulum** (1, p. 16)

Diagnostic characters: Body extremely variable in size, abdomen 0.4–0.8 mm. long, nearly as high, compressed; seen from side, nearly circular, very high, vaulted, with anterior part usually descending steeply; aspis low, oblong, with blunt, full rostrum; rim distinct, well formed, protruding; carina distinct; pseudostigmatic organ short, lanceolate; abdominal bristles very fine, medium-short, often crinkled at base; ventral plate with distinct posterior rim; anal cover bristles I:2 and I:3 long, fairly close; II:1 usually visible anterior to I:2.

This species has already been described and figured in detail (17, p. 223, pl. 33, figs. 1–5).

Size difference: Of the dozen specimens available for study, two belonged to the large size group and were of average size for that group. The smallest specimen was slightly larger than the average size for the small size group. Although this is far too small a number on which to base any size comparison, it may be noted that these Florida specimens show no marked size difference with specimens from the northeastern states.

Distribution: Florida to Connecticut and New York. Epixylous.

The largest and commonest species of this tribe taken in Florida (though from only seven lots out of about seventy-five bearing Oribatoidea).

Florida localities: Wellborn (one specimen: G115), Gainesville (four specimens from three lots: G29, G30, G75), Pinkoson Springs (one specimen: G33), Micanopy (three specimens: G74), White City (one specimen: G108).

6. **Phthiracarus prior** *sp. nov.*

Figures 10, 11

Diagnostic characters: Size small, notogaster averaging 0.34 mm. in length; with very fine, rather short bristles; vertical bristles not discernible; aspal carina lacking; pseudostigmatic organs almost long, scimiter-like; ventral plate without denticles; genital and anal covers quite simple, anal bristles II:1 and II:2 not discernible (not developed).

Dimensions (of two of the four specimens):

Length of notogaster,	344;	of aspis, 217
Height of same,	242;	of aspis, 80
Breadth of same,	226;	of aspis, 127

Thus the notogaster is only slightly higher than broad.

Description: Aspis relatively large, high near distal end; lateral profile of dorsal face convex, with a slight depression at transverse plane of pseudostigmata, rostrum blunt so that the slender rim does not project beyond it; carina not visible; accessory plate notch low, elongate; rostral bristles very fine, inserted well up on rostrum, barely projecting, strongly decurved, fairly approximate (figure 11); other bristles seem to be lacking; angle distant from transverse plane of pseudostigmata; lid short, covering over half the pseudostigmata; pseudostigmatic organs rather long, blade-like, apex incurved (figure 11) and decurved (figure 10).

Notogaster seen from side, high for its length, well curved, barely descending at anterior end, leaving anterior end of abdomen with large aperture thus necessitating the large aspis, descending rapidly behind, thus highest at anterior end; seen from above: oval, broadly rounded behind, anterior edge flattened, slightly impressed above pseudostigmata; collar broad, but little curved; lapet poorly developed; notch shallow, angular; bristles extremely fine and difficult to discern, tapering to a very fine point, usually curved; I:1–5, II:1–4, III:1–3; I:1 just within edge of collar, more remote than I:2, II:1 not or doubtfully discerned; pseudoforamina as in figures 1 and 2.

Ventral plate broadly rounded behind; bristles inserted below edge of plate, rim distinct, no denticles. Genital covers slightly tapering, nearly as broad as long; nubbins poorly developed; bristles nearly as well developed as usual, erect, median series very close together. Anal covers broad, broadly rounded; only bristles I:1 and I:2 visible, rather closely spaced, correspondingly short and fine, I:3 not discerned. The broken line in figure 11 between the two parallel curved lines indicates edge of anal cover under ventral plate.

Closely related to *Ph. setosellum* (17, p. 231) but smaller and, as the name suggests, more primitive or undeveloped as to bristles, and condition of anal and genital covers, lapet, and aspal rim. Its more anteriorly open abdomen may also be a more primitive character.

Occurrence: Pinkoson Springs, Gainesville (three specimens: G33), East Palatka (one specimen: G69). All cotypes.

Phthiracarus curtulus (5, p. 259–260) is recorded from Florida though the type locality is Etruria, Italy. That Phthiracarus was to Berlese in 1923 as Phthiracarini is now understood, is evident from his synonymizing it to Hoplophora of Koch and placing in it *H. cucullatum*, *H. magna*, and *H. carinata* which he makes genotypes for sculptured species in this same paper, thus leaving the smooth species in Phthiracarus *sensu strictu*. The distinguishing characteristic of this species is the pseudostigmatic organs which are, "very short, clavate, barely conspicuous, with a roundly truncate apex." Such an organ I have not yet seen in this family.

Genus **Hoplophorella** (5, p. 260)

Characters: Phthiracarini similar to species of Steganacarus in that the chitin is usually areolated or otherwise sculptured, and the anal covers are strongly convex, thus prominently protruding beyond ventral plate and line of genital covers (as seen in side view) but differing in that the anal covers bear only three, subequally spaced bristles on median edge.

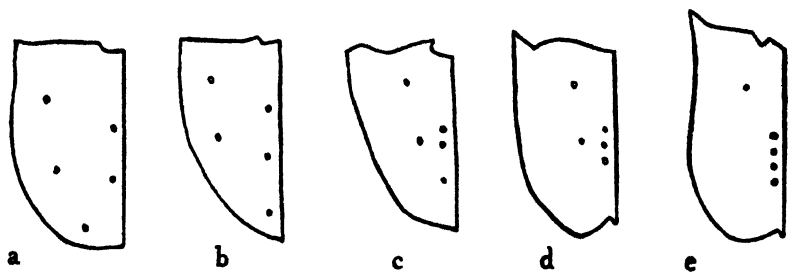
Type: *H. cucullatum* (8, p. 133, pl. 6, fig. 35).

The concentration of the bristles of the anal covers along the median edge as a definite trend among the Phthiracarini becomes evident when one reviews the condition in the various species. For instance, reference to the figures of the species of Phthiracarini of the northeastern states (17, pls. 33–36) shows the typical arrangement of these bristles to be: I:1 and I:2 close to median edge and not closely spaced, and II:3 not close to median edge (17, pl. 33, fig. 5). This is also the condition in the

more primitive genus Hoplophthiracarus. A more advanced stage is where I:1 and I:2 are closely spaced (17, pl. 34, fig. 10) or II:3 come close to the median edge of the covers (17, pl. 34, fig. 18, pl. 35, fig. 21, pl. 36, fig. 28). A still more advanced condition is where I:1 and I:2 are closely spaced and II:3 are on the median edge of the covers (17, pl. 36, fig. 32). This last species is still more advanced in that II:2 are close to the median pair.

In Hoplophorella I:1, I:2 and II:3 have come close together on the median edge and II:2 are usually close to this trio (17, pl. 37, fig. 43,—*Steganacarus thoreaui* thus becomes *Hoplophorella thoreaui* **comb. nov.**).

In Steganacarus II:2 come into line with the median trio forming a median quartette (17, pl. 37, fig. 37).



TEXT-FIGURE 2. ANAL COVER OF: *a*, HOPLOPHTHIRACARUS; *b* AND *c*, PHTHIRACARUS; *d*, HOPLOPHORELLA; *e*, STEGANACARUS

It is interesting to note that the majority of American species belong to the more primitive Hoplophorella while the majority, if not all, of the European species belong to the more specialized genus Steganacarus.

The genotypes of Steganacarus, Tropacarus, Atropacarus, and Trachyhoplophora all have the four bristles on the median edge.

In my earlier paper I referred Tropacarus as a subgenus of Steganacarus. After having examined specimens kindly sent me by F. Grandjean, I am now of the opinion that this species is distinct enough to warrant its being given generic rank.

Thus the more primitive genus Phthiracarus shows considerable variation or groping about in its bristle arrangement, while in the more advanced Hoplophorella and Steganacarus the arrangement has become more set. Likewise one finds that bristles II:2 become specialized in form and stature in these two genera, as well often as the notogaster bristles.

Hoplophorella cucullata (8, p. 133, pl. 6, fig. 35) *comb nov.*

Diagnostic characters: Body rather small (abdomen 0.48 mm. long); oval; greenish grey, yellowish brown where chitin is thicker; sculptured by pockmarking; aspis with broad, squarish (angular) ridge (figure 20); a distinct, angular, flattish, transverse constriction at base of vertical and lateral bristles; carina thrown out to form a conspicuous lateral ridge, leaving a pockmarked area between ridge and carinae; rostral bristles very small, inserted at distal end of ridge, i.e. far above rim of aspis; vertical bristles very short, straight; pseudostigmatic organs long, slender, curved, the edge turned forward, finely rough serrate along distal half; notogaster bristles spoon-shaped, that is with a flattened handle (pedicel) and hollow, bowl-shaped distal portion; genital covers strongly longitudinally constricted (indicated by crenate line in figure 18, undulate line in figure 20); anal cover bristles II:2 broad, blade-like, curved backward near apex, the other bristles fine.

This is a well differentiated species which shows much variation. The variations seem to be locally constant enough to form local races or subspecies.

Hoplophorella licnophorum (4, p. 102, pl. 8, fig. 99) is this species, as it was also described from Columbia, Missouri, and has the same size and characters. The figure shows *angular* areolations of some depth. The holotype of *H. cucullata*, kindly loaned me by Dr. Ewing, has somewhat angular areolations but the areoles are more open, separated by narrow, round shouldered ridges. The coarsest of the Floridian specimens (as no. G75P12) have deep, clean cut, rounded pockmarks with interspaces as wide as the pocks. The holotype of *H. cucullata* has pockmarks on the aspal ridge and in the area between the ridge and the carinae. The Floridian material shows a considerable tendency to lose the pocking and become very thinly chitinized. Anal cover bristle II:2 is figured in *H. licnophorum* as being similar to the other anal cover bristles (!), thus making it similar to the European species (Steganacarus). This is quite certainly erroneous. The holotype of *H. cucullata* is, compared with Floridian specimens, very coarsely sculptured and ridged. For instance the notogastral hood is even higher than in figure 22. The aspal ridge is higher. The carina is highly developed, appearing more like a keel, the upper (dorsal) edge of which is represented by another line parallel to it. Thus there is quite a hollow between the ridge and this carinal keel. I therefore designate the Floridian race as:

7. **Hoplophorella cucullata cuculloides** *subsp. nov.*

Figure 22

Diagnostic characters: Size smaller; pocking more clean cut, of smaller caliber, of rounder pits, stippling strongly developed; aspal ridge not so prominent; carinae much less developed, not forming conspicuous ridges; notogastral bristles relatively longer; anal cover bristles II:2 longer.

Thus this form is dominated by a less degree and less intense development of ornamentation (ridges, sculpturing) but greater bristles.

Dimensions (of only three measurable specimens):

Length of notogaster,	332(362)390;	of aspis, 176(179)197
Height of same,	180(207)226;	of aspis, 74 (83) 90

The holotype of *H. cucullata*, which is very oblique and shattered, has a notogaster 450 by 275.

Occurrence: Milton (one specimen: G62), Gainesville (three specimens from two lots: G6, G75-*Cotypes*), Bonita Springs and Villa Tasso (one specimen each: G95, G101). Thus most of the stations are in west Florida.

H. hamata (8, p. 134, pl. 6, fig. 36) is also one of these subspecies, characterized by entire absence of hood. The "small chitinous band" of the original description is the collar, for the holotype, kindly loaned me by Dr. Ewing, has no hood whatever. The pockmarks are more distinct (see figure) than in the species, including some on the aspis also. These pockmarks are similar to the Floridian *H. cucullata*, i.e., barely angular, deep, and separated by interspaces nearly as wide as the pockmarks. The holotype is mounted obliquely so that nine or ten bristles stand out above the outline of the notogaster. Careful focusing shows these to belong to rows I and II of the further side. Thus there is the usual number of bristles. Furthermore the animal looks long and narrow because of the way it is mounted and viewed. If mounted squarely on its side it would undoubtedly be found to have a more normal length-height ratio. This type specimen differs from the Floridian material in being considerably larger, darker (the Floridian specimens being quite greyish), sculptured with deeper pockmarks and smooth interspaces. I therefore describe it in detail under the name:

8. **Hoplophorella cucullata floridae** *subsp. nov.*

Figures 18–21

Diagnostic characters: Body smaller (abdomen averaging 0.38 mm. long); notogaster *stipple-punctate*, with weakly punctate pockmarkings

which are almost to quite evanescent on *certain* areas of the aspis, genital and anal covers; thinly chitinized individuals show very faint to no pocking—though *the stippling remains quite evident*; no elevated hood on median area, though it is present on the *sides* in all the specimens which I rolled over (see figure 20, which had no indication of a hood in lateral aspect!). Moreover, it is slightly developed in a few specimens (figure 21). It should be noticed that this elevated hood is much more extensive than the collar. Bristles I:1 in both cases originate at the posterior edge of the collar, thus being set well onto the hood when developed. Because of these intermediate specimens and the fact that the hood is developed on the sides of the notogaster without being continuous over the dorsum, I cannot consider the development of this hood as of generic or even specific rank. All intergrades occur! In the material before me, however, most of the specimens are unhooded on median area. On the other hand there are more specimens with a well developed hood on dorsum than with a weakly developed one. Furthermore, this development of a large hood is accompanied by deep, large pockmarks and longer bristles so that two races are distinguishable. A careful study of this hood in its various stages of development shows that it originates as a constriction about the notogaster, followed by a thrusting *forward* and inward of the constriction so as to make the constriction almost underlie the hood as a groove (figure 22, which also shows the deeper corrugation of the posterior portion of the aspis). This constriction thus almost becomes a fold.

The arrangement of the bristles in the earlier descriptions is inaccurate. I find it difficult to locate them all with care even with the twenty specimens at hand. The aspal bristles are not mentioned in the old descriptions but I find, from Ewing's types, that they are as figured on my third plate. Vertical bristles more approximate than notogastral I:1; notogastral bristles I:2 and I:3 slightly more remote than I:1; I:4 and I:5 slightly more remote than I:2 and I:3; II:1 very close to collar. I note that the ventral plate if looked at from ventrolateral aspect appears *below* insertion of VP:1 to 3, from which I infer that it flares inwardly of the notogaster.

Dimensions (of eleven measurable specimens):

Length of notogaster,	336(382)426;	of aspis, 172(192)209
Height of same,	172(213)252;	of aspis, 65 (82) 98

The loss of size with decreased latitude is a common phenomenon.

This species so very much resembles *Hoplophthiracarus histricinum*

in size, color, and texture that some individuals of both species were mounted on the same slide and I at first took them for the same species.

Occurrence: Gainesville (six specimens from three lots: G6, G29, G75-*Cotypes*), St. Augustine (one specimen: G34), Palatka (two specimens: G69), Crescent City (one specimen: G82), White City (two specimens: G108), Bradenton (seven specimens: G87), Bonita Springs (one specimen: G95). Thus from seven localities (out of forty-three) all are from the eastern side of the promontory except two. This subspecies has not therefore been secured from west Florida. Both subspecies are found in the same lots from Bonita Springs and Gainesville. This is undoubtedly due to carriage (anthropophory) at Gainesville but how about Bonita Springs?

9. **Hoplophorella varians** *sp. nov.*

Figures 23–25

Diagnostic characters: Size varying in abdomen length from 0.54 to 0.87 mm.; color brownish; surface strongly areolated; rostrum conspicuously protruding, with quite evident bristles; transverse sulcus across aspis quite marked, vertical bristles too low down on sides to be visible in lateral aspect; pseudostigmatic organs relatively short for this genus; anterior edge of notogaster strongly turned down so that collar is almost vertical; notogastral bristles stout, distal third usually thicker, I:1 often depressed; anal covers strongly and angularly produced along median edge, bristles II:2 stout, long, lance-like, I:1, I:2 and II:3 rather short, rather widely spaced for the genus.

Dimensions (of ten measurable specimens):

Length of notogaster,	543(681)833;	of aspis, 295(353)427
Height of same,	307(400)532;	of aspis, 127(147)168
Breadth (one average indiv.), 480;		246

As the proximal end of the aspis is often covered by the opaque notogaster, I add here length of aspis to the anterior edge of pseudostigmata: 197 (229) 303. I find that in this species oblique length and horizontal (= what?) length are, for all practical purposes, equivalent. The *notogaster* is broader than high but as the genital and anal covers are often fully opened out, thus giving the abdomen much greater height, the animals usually lie on their sides in balsam mounts.

Description: Aspis, seen from side, relatively high (figure 23) with prominently drawn out rostrum, and angular transverse sulcus between

pseudostigmata; seen from above, rapidly narrowing from pseudostigmata; ridge well developed, broad, angular, slightly lower along median line (figure 24); rim slender, not projecting beyond rostrum; carina weakly developed; accessory plate notches distinct, angular; rib short, stout, curved; rostral bristles fairly well developed, inserted far down but remote; vertical bristles short, straight; pseudostigmata with a distinct, broad lid, curving over the more or less seven-scalloped cup; organs angularly bent, fairly stout (as stout as notogastral bristles), thickening towards distal end; sculpturing absent between ridge and sides of aspis, and below carinae, posterior part of aspis with areole ridges straightening out to form slightly radiating ridges.

Notogaster, seen from side (figure 23), elongate oval, fuller than in most species, with the anterior edge turned downward and inward so that the collar is nearly vertical, and forming a rounded angle with dorsal face, this constituting one of the outstanding characteristics; collar not prominent; lapet large, areolated, though not always distinctly so; bristles stout, slightly roughened and thickened towards blunt distal end, I:1–5, II:1–4, III:1–3; I:1 distant from collar, often lying close to notogaster and then shorter and with tapering distal end (in two specimens out of twenty, these bristles resemble the others, and in two or three the bristles are intermediate); some of the bristles of rows II and III, especially the anterior ones, are also bent (figure 24), while bristles II:1 are similar to I:1. Because of the areolation and opacity of the chitin it has been difficult to make these lateral bristles out with certainty; II:1 are unusually distant from collar; I:1 slightly more remote than vertical bristles; I:2 and I:3 slightly more remote than I:1; I:4 almost as approximate as I:3; VP:3 more approximate than I:1. Ventral plate very wide behind, bristles VP:1 slender and inserted well down on sides, VP:2 less so, VP:3 near margin, all three *usually* bent down close to body though they may also be erect. In one individual VP:3 is erect on one side, and slender and depressed on the other! In some individuals VP:3 may be erect while I:1 is depressed. Nubbins well developed. Accessory plate quite prominent in side view (figure 23). Genital covers about as long as anal, anterolateral corners well drawn out, anterior margin rendered undulate by a convex lobe near lateral angle (figure 24), areolated as coarsely as notogaster, though indistinctly so along lateral portion; bristles distinct, though fine, two erect ones on anterior edge (or on accessory plate) (figure 23), three bent ones on median edge and three on anteromedian corner, one of them stouter and inserted well around on to face of cover; center of median

edge of anal covers prominently drawn out so as to form an angle with the posterior edge. In ventral aspect there appears a distinct tooth along this posterior edge (figure 24) which I do not remember seeing in other species, one behind the other; posterior edge also drawn out into a slender ridge which fits into the notch between the denticles, thus preventing tortion and insuring accurate closure; areolation lacking on lateral half, especially posteriorly; bristles fine, rather short, curved backward, rather distant from each other, II:2 specially developed (see under diagnostic characters); median corners highly diversified by development of flanges and flattened teeth in three planes. In figure 25 the outermost plane is drawn with a heavy line, the innermost by a light line, while the intermediate plane, which is usually a tooth or recess, is drawn by a fine line or a dotted line if a recess. Thus the left cover has its corner well drawn out into a long, rectangular, hook-like tooth which fits under the right anal cover and under the right genital cover. The inner flange of the right anal cover is short but drawn out into a prominent triangular, corner tooth. The inner flange of the genital covers is quite long on the posterior edge, but highly undulate on the median edge. In the figure the anterior edge of the left cover is broken away (jagged line). A consideration of this highly complex interlocking region convinces me that these four covers must open and close *together*. Thus in the Euphthiracarini the fusion of the covers of the left side and the fusion of those of the right side to make one cover on each side instead of two is an economy.

From the above it should be evident that this species is quite distinct from any other of the eastern coast and easily recognized.

Occurrence: Gainesville (fifteen specimens from five lots: G29, G30, G75, G76, G84), Pinkoson Springs (one specimen: G33), Orange Heights (one: G48), Micanopy (one: G74), St. Augustine (six out of two lots: G21, G63 = *Cotypes*), Vero Beach (one: G67), White City (three: G108), Cortez (two: G45). Thus the distribution is chiefly eastern; no specimens were taken from southern and western Florida. Those from Orange Heights were taken from spruce-pine needles and small limbs from ground of burned land, the others from various kinds of fallen leaves, from palmetto scrub to shore bay débris. Therefore the species is to be found in a wide variety of leaf mould and at any season.

Hoplophorella cucullata floridae X varians

Five specimens from White City are identical in appearance and are perfect hybrids. They have the following characters of *H. cucullata*

floridae: color, sculpture, shape of bristles of notogaster and anal covers; and of *H. varians:* size, shape of notogaster, genital and anal covers, place of insertion of rostral bristles and of notogastral bristles I:1 and II:1 (as also of the others). Of intermediate nature are: shape of aspis which has the height of *H. varians* but not the rostrum, though the anterior end is oblique—a combination of the two species. The hybrid has distinct aspal carinae extending to accessory plate notch (in the parent species it was short and poorly developed); the rostral bristles are anomalous: short, strongly curved, flattened blades (sickle-like) usually pointing upward, sometimes asymmetrically (like horns of mongrel cows). The vertical bristles are longer than in either parent, stout, rod-like, pointed—much like a lead-pencil but bent toward aspis near apical end. They seem to be inserted distad of transverse sulcus and are quite visible above the aspis in side view; the pseudostigmatic organs are not sharply curved, but undulate, compressed, the distal portion directed forward! The anal covers are sometimes less markedly angular than *H. varians* but just as much drawn out.

To summarize, there are characters distinctly of one parent species, notably the shape of the abdominal bristles, and characters distinctly of the other parent species as the shape of the plates of the abdomen, while some are quite different even to the extent of such unknown rostral bristles which stick out above the aspis like the tusks of a boar. Although both parents occur in the same lots from Gainesville and St. Augustine, this hybrid was secured only at White City, near the southern limit of the range of the parent species. Is this a result of temperature? In the same lot with the hybrids occur two normal *H. cucullata floridae* and three normal *H. varians.*

Tribe EUPHTHIRACARINI (17, p. 241)

Genus **Pseudotritia** (17, p. 242)

10. **Pseudotritia ardua** (18, fasc. 32/15)

As this species has already been figured and described in detail (17, p. 243, pl. 38, figs. 44–51, and pl. 35, fig. 25), only data pertaining to Florida is added. In form this species is typical but it averages smaller.

Dimensions: The figures are taken from nineteen specimens, fifteen of which come from Pinkoson Springs and four (quite within the size range of the Gainesville specimens) from Pensacola.

Length of notogaster,	444(479)554;	of aspis, 222(236)254
Height of same,	275(300)345;	of aspis, 82 (91)103

This average is lower than that of Connecticut specimens, in spite of the fact that the smallest is much larger than the smallest from the northeastern states. Of the twenty-two measured individuals only two were without eggs (presumably males, being near the lower size limit). An individual from Key Largo, larger than the largest Gainesvillian, measures 566, 373; 262, 98 (microns).

Occurrence: Pensacola (four specimens: G61), Gainesville (five specimens from three lots: G6, G77, G109), Pinkoson Springs (twenty-three: G33), Mulberry (one: G103), Key Largo (one: G92). Thus no specimens were secured from the west coast of the peninsula.

Three specimens with a notogaster length of 373 microns, have but one hook to the unguis of legs IV. This is a type of mutation not yet encountered and, if such mutations should receive designatory names, I would call this one **P. a. antetriheterodactylum** *mut. nov.* Thus we have the following combinations:

P. a. monoheterodactylum with one hook on tarsi I–III; three on tarsi IV.
P. a. triheterodactylum with one hook on tarsi I; three on tarsi II–IV.
P. a. antetriheterodactylum with three hooks on tarsi I–III; one on tarsi IV.

The cotypes of this new mutation are on slides G33P3, P5, and P7 (one specimen on each).

11. Pseudotritia ardua sinensis (15, p. 178)

Diagnostic characters: Ungues monohamate.

As this form is differentiated by only one character it is a mutational variation rather than a subspecies (geographical race).

Eight specimens from Pinkoson Springs measure:

Length of notogaster,	398(450)493;	of aspis, 202(208)229
Height of same,	262(281)303;	of aspis, 82 (87) 94

Thus averaging very slightly lower than the species (found in the *same lot*). Fifteen specimens from Gainesville measure:

Length of notogaster,	406(480)574;	of aspis, 205(234)264
Height of same,	262(313)365;	of aspis, 82 (93)106

Thus being practically of the same size as the Pinkoson Springs heterohamate specimens. In other words we have before us specimens with only one hook to the unguis, *living among* individuals with three hooks, and with others that have one hook on some legs and three hooks on the

other legs! Yet Willmann (23, pp. 189 and 194) maintains Pseudotritia as a separate genus for species with only one hook.

Seven specimens from Milton (near Pensacola) measure:

Length of notogaster,	389(443)472;	of aspis, 205(228)242
Height of same,	234(278)291;	of aspis, 74 (89) 98

Thus, like the Pensacola specimens of the triheterohamate form, averaging smaller than the Gainesville individuals.

Four specimens from Vero Beach, and four from White City measure:

Length of notogaster,	467(518)574;	of aspis, 235(254)266
Height of same,	316(344)369;	of aspis, 97 (99)111

Thus, like the Key Largo heterohamate specimen, averaging larger than the Gainesville individuals.

After plotting these various measurements on coördinate paper I find they show remarkable similarity, i.e. the lines are so nearly parallel that I can say there is no modification in proportions. Moreover the addition of the corresponding figures for the *P. sinensis* specimens from China, show such slight difference in proportion as to make the difference barely of academic interest.

In this connection it is significant that in the family Protoplophoridae (9) the larger species have three hooks, while the smallest has but one.

A careful survey of this data, what with my data on the material from the northeastern states, convinces me that these differences in number of hooks on the ungues is of no significance in this species, and are of no systematic interest. It only remains to be determined whether the occurrence of the number of hooks follows Mendelian laws of inheritance. I doubt whether anything is to be gained by separating the monohamate and trihamate specimens—especially in Florida where the two are found in the same lot and of the same size.

Occurrence: Milton (eleven specimens: G62), Madison (one: G23), Perry (two: G10), Mayo (six: G11), Wellborn (one: G115), Gainesville (one hundred and six from twelve lots: G6, 25 specimens, G11, 6, G13, 4, G29, 10, G30, 29, G54, 1, G55, 1, G75, 9, G76, 3, G84, 2, G90, 3, G116, 19), Pinkoson Springs (eleven: G11), Micanopy (five: G28, eight: G74), Green Cove Springs (nine: G80), St. Augustine (one: G21, two: G35), Palatka (two: G69), Crescent City (two: G82), Eustis (one: G105), Mulberry (one: G103), Vero Beach (five: G67), White City (five: G108), Villa Tasso (eight: G101). Thus the distribution in

Florida is quite general but does not extend onto the west coast, as at Bradenton, Cortez, and Bonito Springs. This monohamate form was absent from both the moss samples (from Gainesville), but present in numbers among damp leaves. It seems to avoid pine-spruce needles, for instance it was absent from lots G48 and G61, and but one specimen occurred in lots G54 and G62. It is noteworthy that the monohamate form is by far more abundant than the heterohamate.

Genus **Oribotritia** (16, p. 167)

Characters: Usually large and broad species having bristles absent to medium long (rarely if ever as extremely developed as in the genus Euphthiracarus); aspis usually very long, through extension of the lower part of the abdomen; carina usually well developed; rib fairly well developed; lid usually above pseudostigmata; pseudostigmatic organs usually quite small and fine; median ridge absent; anogenital area often quite narrow but deeply infolded so that detail is best seen in oblique aspect, the bristles much reduced, VP:1 represented by a minute insertion, no interlocking series of ridges; both anal rods and genital shields present; anogenital plates with or without diagonal slit; legs long with stout bristles, the tarsi armed with three hooks, of which the outer are longest; palps with three or four free joints; eggs numerous, slender; not extending as far north as preceding genera.

12. **Oribotritia glabrata** (22, p. 73)

Figures 26–29

Diagnostic characters: Size varying in length of abdomen from 0.58 to 0.91 mm.; color dark tan to chestnut brown; texture finely sanded; pseudostigmatic organ head blade-like with slender pedicel (figure 28), seen from above one sees only the back or edge of the blade (figure 27). In figure 26 it is shown foreshortened below the aspis and end on in the lateral aspect. Bristles long, fine, prone; vertex bristles unusually remote, and close to pseudostigmata; rostral (?) bristles on transverse plane proximad of lateral (!); lateral bristles unusually far from pseudostigmata and close to carinae; notogastral bristles III:1 unusually close to II:1, III:2 also unusually high up on sides; III:3 almost between II:4 and VP:2; VP:3 far from posterior end of abdomen.

Dimensions (of five measurable specimens):

Length of notogaster,	578(820)913,	of aspis, 314(407)467
Height of same,*	365 — —;	of aspis, 119 — —
Breadth of same,**	— 586 —;	of aspis, — 320 —

* of one unusually small specimen
** of one medium sized specimen

Description: Aspis unusually broad at anterior end (figure 27), with a distinct carina; posterior border thickened, curved distad to project ectad of pseudostigmata as a shelf *below* them; rim slender, projecting beyond sides of carinae; no discernible lid; pseudostigmatic cup with about eleven radial sectors visible from side, the largest on proximal side.

Notogaster (figure 26) narrower than high, seen from above or the side bluntly angled behind, high in front; collar narrow; notch very open, merely an undulation; lapet long, slender; bristles very fine, I:1 rather distant from collar, I:5 low down, on ventroposterior angle, III:1 also distant from collar, at least more so than II:1 and unusually close to it, III:3 close down to VP:2, thus III:2 and III:3 are quite remote, VP:3 distant from posterior end of abdomen.

Genital shields with but six pairs of bristles evident, strap-like, i.e., as broad anteriorly as posteriorly; the two bristles on each anogenital plate inserted far forward, the anterior one almost on rim; anal rods with two pairs of bristle insertions, one on head the other (bearing a long, fine bristle) on transverse plane between rudimentary VP:1 and VP:2; two pairs of bristles on rim of anal section of anogenital plates, one pair on transverse plane between VP:2 and VP:3, the other bearing a slender bristle on transverse plane closely posteriad to VP:3. The posterior pair of anal rod bristles and the anterior pair of the anal section of the anogenital plates are caducous and seldom seen. An individual with a break across the anterior part of the genital field shows that the lower edge of the notogaster (represented by a heavy line in figure 29) is rounded or bluntly folded upward and inward, and that the edge of the plate meets the edge of the anogenital plate at a very acute angle, evidently being connected by a thin membrane. Figure 26 is that of a small, pale individual, the only one out of the dozen specimens not mounted obliquely.

Occurrence: Gainesville (five specimens from four lots: G6, G75, G109, G111), Edgar (near Hawthorne), Green Cove Springs (one specimen each: G80, G81), Bradenton (three: G44), Cortez, White City

(one each: G45, G108). Thus from both the east and the west side of the peninsula though not from the west or south ends of the state. One specimen was from "true moss," the others from various fallen leaves. Say's specimen came from "Georgia and east Florida."

Identity: This species is referred to Say's name because it is the commonest species of this genus. It is true that Say gives no characters of generic value. The only specific characters given are: glabrous, black, under stones. It is evidently fairly frequent and probably large enough to be fairly easily seen. No species of Floridian Phthiracarid is glabrous. Say undoubtedly could not see the extremely fine bristles which are visible only under high magnification and special illumination. There are no black species of Phthiracarini, in fact these species are usually quite pale. *Ph. sphaerulum* has an abdomen 0.4–0.8 mm. long, so that the present species averages slightly larger. Furthermore the present species though a rather dark brown by transmitted light is probably quite dark in life. I know of no Phthiracarids that are black or blackish. Steganacarus and Hoplophorella are the darkest of the Phthiracaridae but these have very stout and conspicuous bristles. *Pseudotritia ardua*, the commonest Phthiracarid, is quite compressed and pale in life color. Thus every indication is toward the present reidentification. Say's specimens are not at the Philadelphia Academy.

13. **Oribotritia carolinae** (17, p. 257, pl. 42, figs. 73–76)

Figures 30–32

Diagnostic characters: Size fairly large (length of abdomen 0.85 mm.); color amber; texture finely sanded; anterior rim of aspis strongly retracted; pseudostigmatic organs rather long, flagellar; bristles short, erect, vertex bristles distant from pseudostigmata and on transverse plane distad of them; lateral bristles close to carina and far from pseudostigmata; two carinae; lid very well developed; VP:3 at posterior corner of abdomen; bristles of anal area rarely present.

Dimensions (of five specimens):

Length of notogaster,	800(851)891;	of aspis,	345(399)425
Height of same,	552(578)611;	of aspis,	— 145 —
Breadth of same,	— — —;	of aspis,	— 272 —

These measurements reveal an unusually short aspis compared with height of notogaster. This is due to the great depression of the notogaster anterior to its center and again above the aspis.

Description: Aspis sanded between pseudostigmata, smooth below carinae; rather small, anterior end strongly contracted to form a distinct rostral area (figure 31), posterior edge with a stoutly thickened, very slender, chitinous rim, and a much thinner, broad band; rim projecting beyond carinae; the upper carina is blunt, the lower sharp, fine; anterior and lateral slope marked by fine, undulate combing, more marked than in *O. banksi*; rostral bristles quite close, their insertions strongly marked; although the two pairs of posterior bristles in figure 31 seem to be inserted far more distad than in figure 30, both are camera lucida tracings and therefore the difference is due to angle of vision on these curved faces.

Notogaster seen from side (figure 30) very much curved, anterior profile descending rapidly, similarly to posterior, then bending down again above aspis, lower edge of posterior end also constricted; collar narrow; notch very deep; lapet very slender, very oblique, lower end tapering to a point; bristles rather short, rather fine, curved, I:1 far from collar, I:5 so high up as to occupy the place usually held by I:4, thus the whole row much more crowded than usual, II:1 correspondingly distant from collar, II:4 correspondingly high up on sides, III:1 in the very marked angle of the lapet, thus very low down and anterior, III:2 also low down on sides and on transverse plane between II:1 and II:2, VP:2 somewhat more posterior than usual. Thus the whole bristle arrangement is quite different from *O. banksi* which it resembles in aspal sculpture, and in lateral profile of notogaster (except the lapet).

Anogenital area quite slender; anogenital plates closing genital area over quite completely then cut back sharply to sides of opening and gradually covering over posterior three-fourths of the anal area. Thus the genital shields are completely covered; anterior edge strengthened by a projecting band of chitin (figure 30); a single pair of bristles inserted near ental edge of plate not far from anterior end (figure 30); a diagonal slit along sides, originating at lateral angles (figures 30 and 32); a pair of bristle insertions at posterior third of anal section. Genital shields covered over by genital plates; the bristles present, inserted on a slender rib; anterior edge thickened. Anal rods with faint bristle insertions on head, no other insertions discernible, median edge thicker and twisted in at least two places (posterior twist only shown in figure 32).

Palps three segmented, but proximal segment has a faint, pale ring about it where joint of the second would normally be (they appear to be four segmented in the original figures).

Occurrence: White City (five specimens: G108) and Fort Lauderdale (one specimen: G113), thus both from the southeast coast. The cotypes came from the Black Mountains of North Carolina and are not before me for comparison.

FREQUENCY OF OCCURRENCE

In the following table, the 258 specimens collected are referred to their respective species and genera. The numerals in parentheses record the number of lots in which each species was found.

Aedoplophora major	4 (1)	genus 4
Hoplophthiracarus histricinum	22 (5)	
Hoplophthiracarus robustior	14 (1)	
Hoplophthiracarus grossmani	2 (2)	genus 38
Phthiracarus sphaerulum	12 (7)	
Phthiracarus prior	4 (2)	genus 16
Hoplophorella cucullata floridae	20 (9)	
Hoplophorella cucullata cuculloides	6 (5)	
Hoplophorella varians	30 (13)	
Hoplophorella cucullata X *varians*	5 (1)	genus 61
Pseudotritia ardua	34 (7)	
Pseudotritia ardua sinensis	187 (28)	genus 221
Oribotritia glabrata	12 (9)	
Oribotritia carolinae	6 (2)	genus 18

Thus the commonest species, arranged in order of abundance, are: *Ps. ardua sinensis*, *Ps. ardua*, *H. varians*, *Hph. histricinum*, *H. cucullata floridae*, *Hph. robustior*, *Ph. sphaerulum*, *O. glabrata*.

Of the forty-three lots, eleven yield only *Ps. ardua sinensis.* Only twelve lots yield three or more species. Lot G108 (White City) contains the largest number of species (seven), namely: *Ph. sphaerulum* (1), *H. cucullata floridae* (2), *H. cucullata* X *varians* (5), *H. varians* (3), *Ps. ardua sinensis* (5), *O. glabrata* (1), *O. carolinae* (5). Lot G75 (Gainesville) has six species much as the above; and G33 (Pinkoson Springs) also yields six: *Hph. grossmani* (1), *Ph. sphaerulum* (1), *Ph. prior* (3), *H. varians* (1), and *Ps. ardua* and variety (34). Fourteen lots from Gainesville net eight species.

By contrast, eleven species, seven of them belonging to the genus Phthiracarus, have been taken from one locality in Connecticut. Some of these are possibly introduced from Europe. Two are found in Florida, *Ph. sphaerulum* and *Ps. ardua*.

ECOLOGICAL DATA

Of the three important niches occupied by Phthiracarids, decaying wood, moss, and leaf mould, in the present collection the first niche was entirely overlooked and the second is represented by only two lots. This collection lends itself, therefore, to a study of the preference and restriction of box mites to particular kinds of leaf mould.

From seventeen different kinds of leaves, and of various degrees of dampness and dryness, one must draw the conclusion that these mites are quite impartial to the kind of leaves they find, except that they are not abundant or even common among pine and spruce leaves (with the exception of lot G61 where thirteen specimens of *Hph. robustior* were found). Lot 33, bearing six species, two of them uncommon, might seem to favor hickory leaves but *Ph. prior* was also taken from live oak leaves and *Hph. grossmani* was also secured from shore bay debris. Thus there must have been other factors which made locality G33 a favorable one.

A careful study of the species under each lot reveals rather that such extreme niches as those of lots G21, G23 (pine), G28 (cultured), G34, G35, G48 (burned land, spruce and pine), G54 (pine), G55 (pine), G81 (too new), G84 (too dry), G90 (too dry), yield but very little, usually one specimen of *Ps. ardua sinensis.* Lots of dry leaves inevitably yield few specimens of the most frequent species. Lots from shady and moist niches give most species and individuals. Undoubtedly the most undisturbed land, with plenty of leaf mould, will make the most interesting collection. In brief, extreme conditions, as sea oats on the sandy beach, or dry, sunny pine land, do not yield specialized species, but the most tolerant species—in this subfamily.

An attempt has been made to correlate the occurrence of species with soil types (12) but without success. No attempt has been made to correlate distribution with the types of vegetation (10, 11, 13) which would only affect local occurrence (6, p. 290). For such correlations, collecting would have to be carried on with this object in view.

GEOGRAPHICAL DISTRIBUTION

The distribution of the different species may be visualized by means of the following table:

Aedoplophora major	south tip
Hoplophthiracarus histricinum	w. and w. coast

Hoplophthiracarus robustior	w. Fla.
Hoplophthiracarus grossmani	peninsular
Phthiracarus sphaerulum	peninsular
Phthiracarus prior	northcentral
Hoplophorella cucullata floridae	peninsular
Hoplophorella cucullata cuculloides	w. and w. coast
Hoplophorella varians	peninsular
Hoplophorella cucullata X varians	e. coast
Pseudotritia ardua	except w. coast of pen.
Pseudotritia ardua sinensis	same
Oribotritia glabrata	peninsular
Oribotritia carolinae	e. coast

Thus, as far as we now know, there is one species confined to the southern tip, two to the east coast, one to northcentral, one to extreme west Florida. Five are peninsular, two are found along the west coast, two are found throughout Florida though not yet on the west coast.

The holarctic *Ps. ardua* is found from end to end of the state even to Key Largo. The New England *Ph. sphaerulum* is found almost throughout the peninsula. The Mississippi valley *Hph. cucullata* is also found as a variety throughout the peninsula. *O. glabrata,* extending from the southern edge of Connecticut, is also peninsular.

One wonders why the commonest form, *Ps. ardua sinensis,* is not found on the west coast of the peninsula, though found in extreme west Florida? *H. cucullata cuculloides* being found along the west half is more closely related to the species than *H. cucullata floridae* which I do not find from west Florida. These two subspecies overlap.

Although our knowledge of the West Indian and central American species is extremely meagre, one can definitely state that *Aedoplophora major* is of tropical abstraction being very closely related to *Ae. glomerata* of Venezuela, and that no other species seem to have tropical affinities. On the other hand six species are definitely known to extend far to the northward. This ratio of geographical affinities corresponds fairly well (remembering the regrettable state of our knowledge of this group) to that for the Odonata (6, p. 271) which is:

Nearctic	about 60%	
Neotropic	23%	
Endemic	17%	
Found in Connecticut	35%	(25% for box mites)
Found in Indiana	42%	(unknown)
Cosmopolitan	14%	(two out of thirteen)

Temperature was judged to be the most important factor influencing distribution in the Odonata (6, pp. 292–300), and the state was divided

into three or four sections on this basis. This has been reproduced in text figure 1. The broken lines are the isotherms for 54°, 61° and 66°, the average temperature for January. The distribution of the Phthiracaridae does not seem to correspond to this factor but rather to physiography.

As Florida has been a peninsula from Miocene time, it has had far more time to become populated than glaciated New England, yet its box mite fauna is more meagre. It is impossible at present to state if evolution has gone further.

ITHACA, N. Y.

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EXPLANATION OF PLATES

PLATE 19

Aedoplophora major *sp nov.*, adult

Fig 1 Pseudostigmatic organ head; free hand.
Fig. 2. Lateral aspect, pygidium almost completely retracted, only distal part of one foot included, mouth parts omitted; ratio 200.
Fig. 3 Anterolateral rim of pronotaspis showing collar; ratio 200.
Fig. 4 Ventral aspect, slightly oblique, appendages omitted; ratio 200
Fig. 5. Aspis, slightly oblique; ratio 200
Fig. 6 Pleuraspis, ectal view (ridges indicated by broken lines), with an anal cover (the underlying parts outlined by means of dotted lines); ratio 200
Fig. 7 Anal covers seen obliquely with articulation arm passing under apodeme flange; ratio 200.
Fig. 8. Edge view of an anal cover showing articulation arm; free hand.
Fig. 9 Distal three segments of palp; ratio 440.

PLATE 20

(All figures are of the same magnification, with legs and mouth parts omitted).

Phthiracarus prior *sp nov*, **adult**

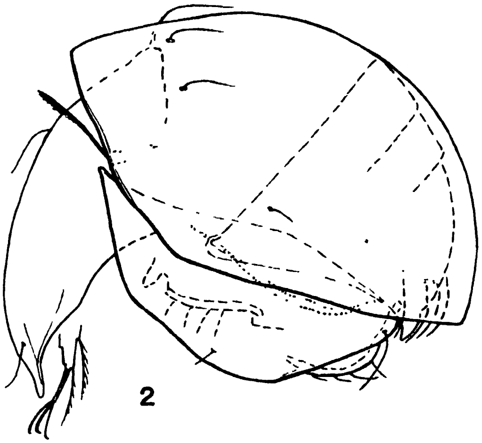
Fig. 10. Lateral view.
Fig. 11. Dorsoventral.

Hoplophthiracarus grossmani *sp. nov.*, adult

Fig. 12. Lateral view.
Fig. 13. Dorsoventral; the pseudostigmatic organs broken.

PLATE 19

1



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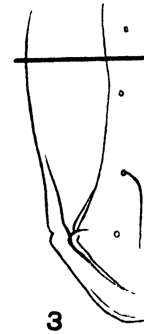

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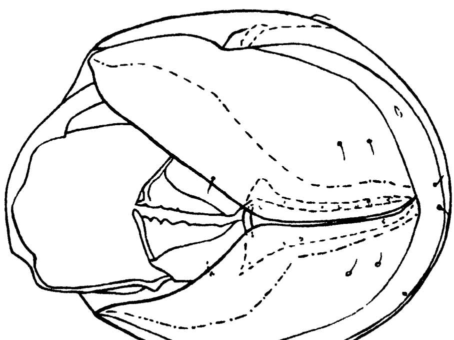

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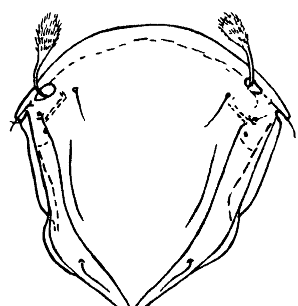

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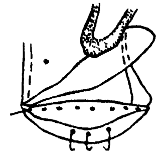

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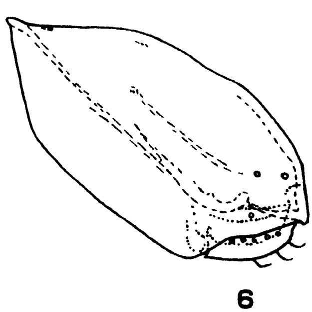

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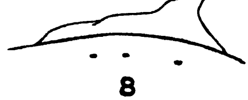

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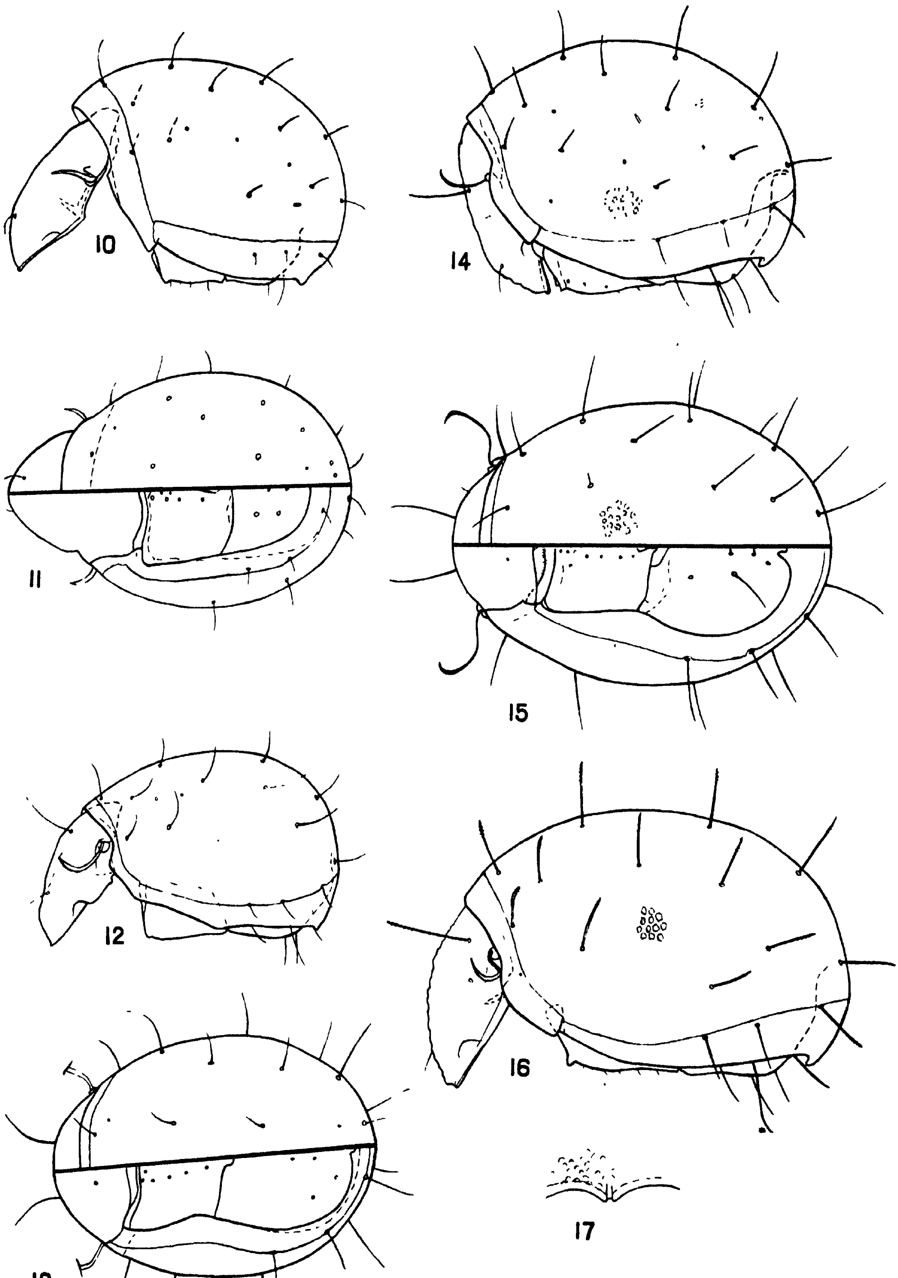
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PLATE 21

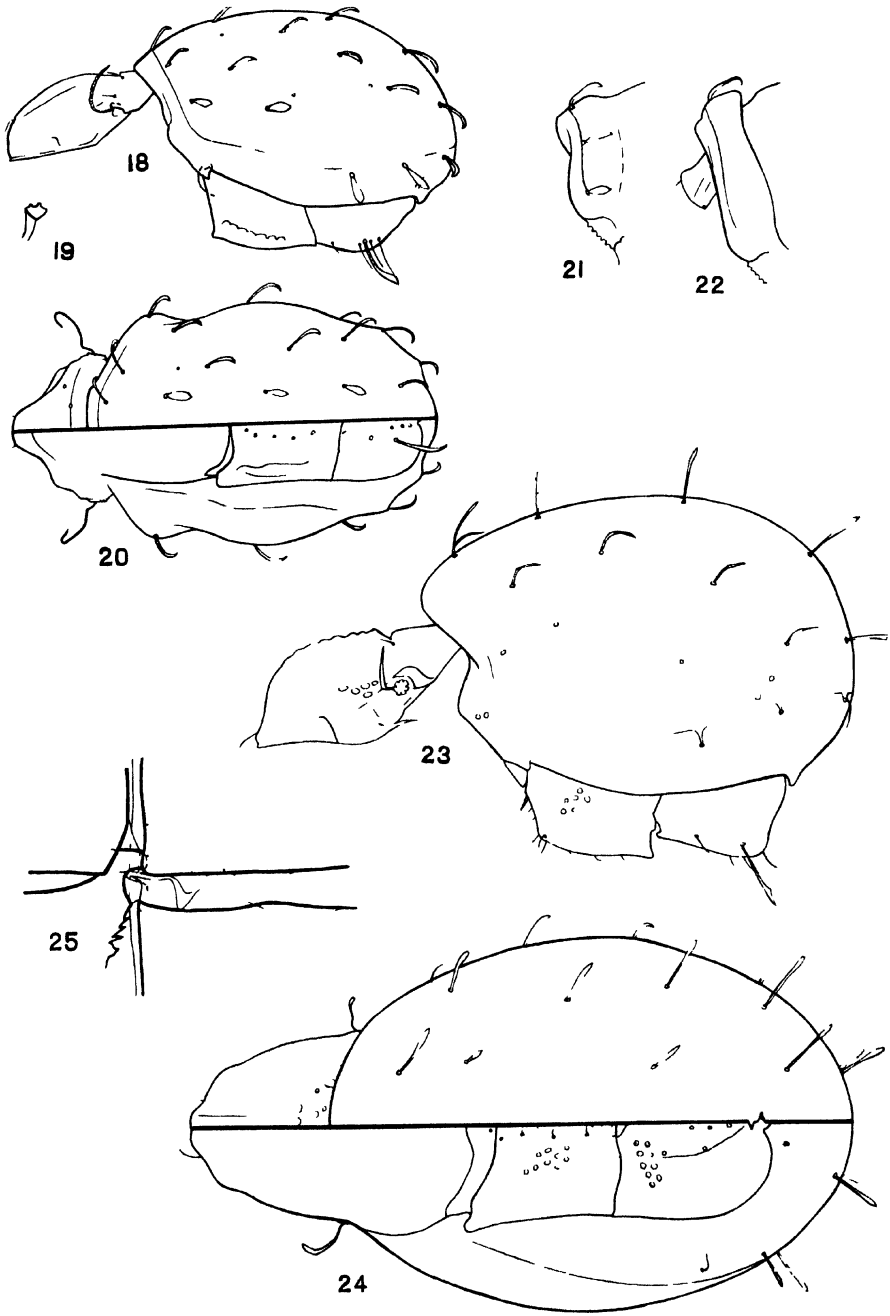
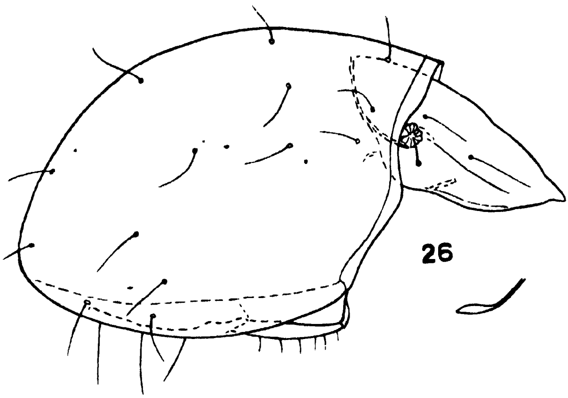


PLATE 22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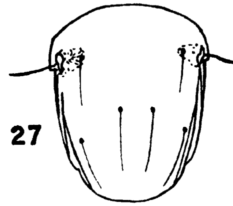
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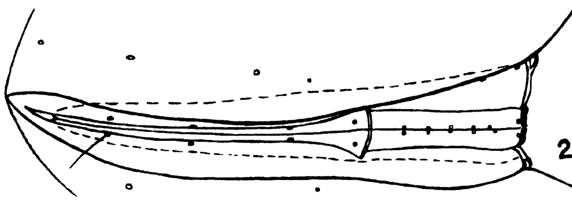
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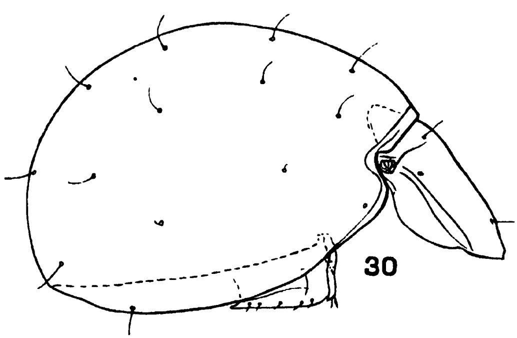
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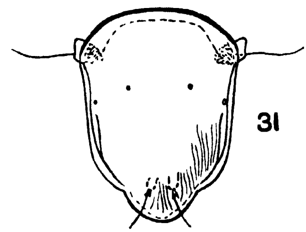
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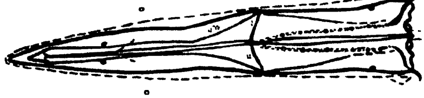
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Hoplophthiracarus histricinum (2, p. 12), adult

Fig. 14. Lateral view; nearly closed.
Fig. 15. Dorsoventral; crosshatched area is the opening between aspis and accessory plate.

Hoplophthiracarus robustior *sp. nov.*, adult

Fig. 16. Lateral view.
Fig. 17. Denticles and notch of ventral plate, viewed at right angles to plate.

PLATE 21

Hoplophorella cucullata floridae *subsp. nov*, adult

Fig. 18. Lateral view, legs and mouth parts omitted; ratio 100.
Fig. 19. Notogastral bristle seen from end, showing two carinae on dorsal face; free hand.
Fig. 20. Dorsoventral view; ratio 100.
Fig. 21. Anterior end of notogaster of a specimen with low hood; ratio 100.
Fig. 22. Anterior end of notogaster of a specimen with high hood, i.e. **H. c. cu-culloides** *subsp. nov.*, including corrugated area of aspis; ratio 100.

Hoplophorella varians *sp. nov.*, adult

Fig. 23. Lateral view, legs and mouth parts omitted; ratio 100.
Fig. 24. Dorsoventral view; ratio 100.
Fig. 25. Contact area of anal and genital covers; ratio 200.

PLATE 22

Oribotritia glabrata (22, p. 73), adult

Fig. 26. Lateral view, legs and mouth parts omitted; ratio 100 (unusually small specimen).
Fig. 27. Aspis, dorsal aspect; ratio 60.
Fig. 28. Pseudostigmatic organ, seen from side; ratio 440.
Fig. 29. Anogenital area; ratio 100.

Oribotritia carolinae (17, p. 257), adult

Fig. 30. Lateral view, legs and mouth parts omitted; ratio 60.
Fig. 31. Aspis, dorsal view; ratio 75.
Fig. 32. Anogenital area, plates slightly open; ratio 100.

A NEW SPECIES OF CONRADINA FROM TENNESSEE

By H. M. Jennison

The occurrence in Tennessee of a species of *Conradina* has for years been known to a few plant collectors and others interested in Botany. It is believed that Dr. A. Gattinger, pioneer botanist in Tennessee, knew in a general way of its occurrence in the northern part of the Cumberland Plateau country in Tennessee, but it is doubtful if he ever collected it. At any rate no one of the plants listed in Gattinger's Flora of Tennessee (1901) can be the species in question. The late Albert Ruth, of Fort Worth, Texas, formerly Superintendent of Schools in Knoxville, Tennessee, is reported to have visited the station near Rugby, Tennessee, where this mint grows. Whether he ever collected and distributed it is not known to the writer. Mrs. Charles Brooks, a resident of Rugby, Tennessee, knows where the "Rosemary" grows and has cherished it for many years.

The writer visited Rugby and vicinity about July 1st, 1930, and was guided by Mrs. Brooks to the station where the *Conradina* plants grow. No collections were made at that time since the plants were not in bloom, but on May 16, 1931, the writer, in company with Professor A. J. Sharp, visited the locality again and finding the plants in bloom collected several specimens. Upon critical examination it was discovered that the Rugby plants were not like either one of the 3 species known to science. Additional collections were made and sent to us last summer when further study made it apparent that the *Conradina* in question was sufficiently distinct to warrant describing it as a new species.

At present the writer knows of no station except the one near Rugby where this species grows.

CONRADINA VERTICILLATA sp. nov.

Arbuscula; ramuli passi, radices facile agentes; stamina cylindrata, cortex fulvus, cito cadens; virgulta quadrilatera, rufa, primo puberulentia; folia linearia, fasciculata specie, adversa, margines revolutae, facies dorsalis glabrata, viridis, glandulosa, facies ventralis cana, venxa

media prominens; flores 2–6 in brevi pedicello, fluxis verticillis, vel summo cacumine; calyx hirsutus, validis 13-nervis, labrum superius tribus fibris, inferius bidens, paulo longius superiore; corolla purpurans, labrum inferius 3-fibris (maxime purpurans), maculosum intus, labrum superius fornicatum, retusum; stamina per duo paria, inclusa intra labrum superius, fila curvata, antherae variae, parallelae; genus bifurcum, exsertum; nuculae quattuor, globosae, glabrae; mense Maio floret.

An undershrub with diffuse branches, the lowermost rooting freely; stems cylindrical with brown bark that shreds and sloughs off as the branches enlarge; twigs 4-sided, rufous, at first puberulent; leaves linear, opposite, appearing fasicled, average length 17.0 mm., average width 1.2 mm. (exsiccatae), margin revolute; dorsal surface glabrate, green, glandular-pitted, ventral surface hoary, midrib prominent; petiole inconspicuous, 1 mm. or less in length; flowers 2–6 on short pedicels in loose verticils, or terminal; calyx 6–7 mm. long, hirsute, strongly 13-nerved, the upper lip three lobed, the lower two-toothed and slightly longer than the upper; corolla lavender, lower lip 3-lobed and strongly spotted within, upper lip arched, retuse; stamens in two pairs, opposite, included within the upper lip, filaments curved, anthers versatile, parallel; style forked, slightly exerted; nutlets 4, sphaeroidal, smooth, brown, about 1 mm. in diameter. Blooms in May.

Type, Jennison and Sharp 31–432, collected on sandy beach, north bank of the Clearfork River (Fentress Co.) near Rugby, Tennessee, May 16, 1931, and deposited in the University of Tennessee herbarium. A close relative of the coastal plain species of *Conradina*, but readily distinguished by its verticillate inflorescence and glabrate leaves.

The writer is indebted to Dr. A. W. McWhorter for composing the Latin diagnosis.

DEPARTMENT OF BOTANY,
UNIVERSITY OF TENNESSEE,
KNOXVILLE, TENN.

FUSION BETWEEN LYMPH BALLS OF A REGULAR SEA URCHIN (LYTECHINUS) AND A SAND DOLLAR (MELLITA)*

By Rebecca Ward

With One Text Figure

The lymph of *Lytechinus* (*Toxopneustes*) *variegatus* (Lamarck) contains five types of cells corresponding to those listed for *Arbacia punctulata* by H. V. Wilson 1924. Reference is made in Wilson's paper to the descriptive accounts of such cells by J. E. Kindred 1921, 1924, Goodrich 1919, and other investigators. A later paper by Kindred, 1926, adds to our knowledge of the Arbacia cells.

It is not necessary to the purpose of this investigation to consider in detail the structure of the lymph cells. The data here set down will suffice. In Lytechinus the lymph contains:

1. Colorless cells with rounded body about 10μ in diameter and numerous pseudopodia. The pseudopodia are doubtless lamellate although with a 4 mm. objective they appear to be filose and 14–18μ in length. These cells correspond to the leucocytes of Goodrich and Kindred.

2. Colorless cells usually elongated and varying in length from 18–25μ They exhibit amoeboid motion and change of shape without the formation of conspicuous pseudopodia

3. Red amoeboid cells, quite similar to the preceding in shape and behavior but smaller, measuring 14–18μ in length.

4. Rounded yellowish green cells about 10μ in diameter are present but in small numbers.

5. Spheroidal, doubtless flagellate, cells about 7μ in diameter, which move very rapidly with a rotary motion.

The key-hole sand dollar *Mellita pentapora* (Gmelin), often desig-

* This work was carried on at the Biological Laboratory of the U. S. Bureau of Fisheries at Beaufort, N. C. The writer is indebted to the Commissioner, Hon Henry O'Malley, for the privilege of working at the station and to the Director and staff for aid and courtesies, and to Professor H. V. Wilson for suggesting the problem here reported on and for his helpful criticism.

nated *M. testudinata* Klein and sometimes *M. quinquiesperforata* Leske, although it belongs to a different order (Clypeastroida) from Lytechinus (Regularia), has lymph cells essentially like those of the latter except that the spheroidal, rapidly moving (flagellate) cells seem not to be present. They were at any rate not observed in Mellita.

"Clotting" of lymph takes place in both species but more rapidly in the case of Lytechinus, probably on account of the greater number of leucocytes in this form, since it is primarily through the activities of these cells that the clot is formed. The clumps of cells produced soon acquire a smooth surface due to the differentiation of a delicate limiting membrane from which pseudopodia are thrown out.

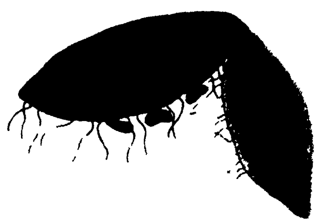

FIG. 1 MARGINAL REGION OF COMPOSITE MASS IN PROCESS OF FORMATION BY FUSION OF LYMPH BALLS OF MELLITA AND LYTECHINUS

The Mellita ball is the darker Drawn at 3 p.m.

If now, two such masses, one light red and consisting of Lytechinus cells, the other dark red and consisting of Mellita cells, are brought in contact they begin to fuse. The fusion progresses and is eventually complete, the two masses becoming differently colored regions of one continuous whole. In a particular experiment the two masses used were sub-spheroidal, about 0.25 mm. in diameter, and smooth. Using needles and pipette they were brought in contact in a culture dish. Shortly afterwards, at 3:00 P.M., considerable fusion was observed to have taken place. The masses at this time were examined microscopically under a supported cover glass. In one of the reëntering angles and in its neighborhood the pseudopodia of the two masses could be seen constantly changing in 'pseudopodial play' (Fig. 1). Entangled among them and in the meshwork which the two sets of pseudopodia made some free cells, particularly the red amoeboids, could be seen as shown in the figure.

The fusing masses were reëxamined under the microscope at intervals during the afternoon. The plane of fusion was for some hours indicated by a constriction of the whole mass and by a fairly sharp line running across it. This constriction and the line gradually faded out and by 8:30 P.M. had disappeared. The combination mass at this time was ellipsoidal with smooth surface. About one-half of it, representing the Lytechinus tissue, was light red, the other half, representing the Mellita tissue, was dark red.

H. V. Wilson, 1924, has already reported that lymph balls of the two regular sea urchins *Arbacia punctulata* and *Lytechinus* (*Toxopneustes*) *variegatus* will fuse when brought in contact. He remarks upon the contrast in behavior between the sea urchin lymph balls and the, in some respects, analogous reunition balls of dissociated sponge cells. This contrast is intensified by the case here recorded.

LITERATURE REFERENCES

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WILSON, H. V. 1924 Amoeboid behavior of the lymph cells in sea urchins. Jour. Elisha Mitchell Sci. Soc **40**: 169.

BINARY SYSTEMS OF m-NITROTOLUENE AND p-NITROTOLUENE WITH NAPHTHALENE, p-TOLUIDINE, AND o-NITROPHENOL

By H. D. Crockford and N. L. Simmons, Jr.

In this paper are given the data for the temperature-composition diagrams for the systems: n-nitrotoluene with naphthalene, p-toluidine, and o-nitrophenol and p-nitrotoluene with p-toluidine and o-nitrophenol. This work is a continuation of a series of investigations on the nitrotoluenes which have been carried out in the Department of Chemistry of the University of North Carolina. Data for the system: p-nitrotoluene-naphthalene have been determined by R. Kremann.* From the data have been calculated the heats of fusion of the various compounds.

PURIFICATION OF MATERIAL

The materials employed were the purest grade of Eastman chemicals. The p-nitrotoluene and naphthalene were purified by four crystallizations from hot carbon tetrachloride. Attempts to purify p-nitrotoluene from hot ethyl alcohol were not successful. The m-nitrotoluene was purified by repeated fractional crystallizations from its own melt. The p-toluidine was recrystallized three times from hot carbon tetrachloride and further purified by crystallizations from the molten material. The o-nitrophenol was crystallized four times from hot ethyl alcohol. The following constant melting points were obtained: p-nitrotoluene 51.4°C.; m-nitrotoluene 15.6°C.; p-toluidine 43.4°C.; naphthalene 80°C.; and o-nitrophenol 44.9°C. These values are corrected for stem exposure. It is to be noted that the value for o-nitrophenol is about half a degree higher than the value given by most investigators.

EXPERIMENTAL PROCEDURE

The data were obtained by the cooling curve method. The materials were weighed out into a test tube one inch in diameter. For

* R. Kremann, Sitzungsberichte Akademie der Wissenschaften in Wien. Mathematisch-Naturwissen-Schaftliche Klasse. 113, IIB: 864. 1904.

the m-nitrotoluene a weighing pipette was employed. This test tube was air-jacketed by a larger test tube which was, in turn, placed in a bath of water, or ice, salt, and water, in a large beaker which was in turn insulated from the surroundings by another air-jacketed beaker of larger size. The whole was covered by asbestos board. In this way the heat loss of the bath during the cooling of the mixture was cut to a minimum. The bath was usually maintained at a temperature about five degrees below the freezing point of the melt. Thermometers graduated in 1/10 degree intervals and calibrated against Bureau of Standards thermometers were employed. Stirring was effected by a glass loop stirrer around the thermometer bulb. All temperature data are corrected for stem exposure. Some trouble was encountered with super-cooling in the mixtures employing m-nitrotoluene as the solvent. By seeding this was kept to a minimum. The method of Bell and Herty* in the interpretation of the cooling curves was employed. This method has been criticized as inaccurate but with a minimum of super-cooling concordant results can be obtained. The data given are easily accurate to .1° and check values were obtained on all solutions (see table 1).

RESULTS AND CONCLUSIONS

An examination of the data shows that all the systems studied are simple ones showing no tendency to compound formation. It was not thought necessary to draw the temperature-composition diagrams. If the values of $\log_{10} X$ (X = mol fraction of solvent) be plotted against the reciprocal of the absolute freezing point of the mixtures, approximately straight lines are obtained in all the cases studied. It may therefore be concluded that these systems are at least nearly ideal in nature. From the slopes of these lines the latent heats of fusion have been calculated. The values obtained are given in table 2.

The values for the heats of fusion show about a two per cent variation in the values obtained for the various melts in any one system except for the values for m-nitrotoluene which show a somewhat greater variation. It is to be noted that the agreement for any one compound from system to system is good except for the m-nitrotoluene. It should be pointed out that this is the lowest melting compound studied, the one in which the smallest number of points was secured in any one system, and the component with which very small errors in melting point would make

* Bell and Herty. J. Ind. Eng. Chem. 11: 1124. 1919.

TABLE 1

DATA OBTAINED BY USING METHOD OF BELL AND HERTY

MOL PER CENT p-NITROTOLUENE	p-NITROTOLUENE — p-TOLUIDINE Freezing point	Eutectic
	°C	
100	51 4	—
89 54	45 7	-
78 81	39 2	—
61 77	28 0	15 94
54 54	22 6	15 84
37 31	22 6	15 84
24 49	30 45	—
14 41	36 1	—
9 22	38 9	—
0	43 4	—
	p NITROTOLUENE — o NITROPHENOL	
100	51 4	—
92 43	47 55	—
82 19	41 7	—
75 26	37 4	—
64 40	29 65	16 9
54 78	22 7	16 9
49 42	18 2	16 9
44 02	19 10	16 9
32 13	27 40	16 9
19 32	35 00	-
6 33	41 75	—
0	44 9	—
MOL PER CENT m-NITROTOLUENE	m NITROTOLUENE — p-TOLUIDINE	
100	15 6	—
96 49	13 8	—
89 72	10 3	—
81 52	5 4	−2 6
68 79	− 9	−2 7
60 48	2 95	−2 4
44 76	16 50	−2 5
42 07	18 40	—
25 99	29 15	—
25 20	29 65	—
17 45	34 00	—
12 14	37 00	−2 6
0	43 50	—

TABLE 1—*Concluded*

MOL PER CENT *m*-NITROTOLUENE	*m*-NITROTOLUENE — *o*-NITROPHENOL	
	Freezing point	Eutectic
	°C.	
100	15.6	—
90.43	10.75	—
80 28	5.2	—
70.17	.00	−1.45
62.90	3.00	−1.60
49.05	15.50	−1 55
39 09	22.40	—
34 17	25.9	—
24.44	32.0	—
9.58	40.0	—
5.96	41.9	—
0	44.9	—
	m-NITROTOLUENE — NAPHTHALENE	
100	15.6	—
95.74	13.15	—
90.29	9.71	4.6
80 78	4.85	4.8
71.57	17.2	4.6
57.53	35.2	4.9
49.57	43.8	4.85
41.50	51.4	—
29.22	61.3	—
18.91	68.5	—
0	80.0	—

TABLE 2

LATENT HEATS OF FUSION

SOLVENT	SOLUTE	HEAT OF FUSION, CALORIES PER MOL	
		Solvent	Solute
p-Nitrotoluene	*p*-Toluidine	3,970	4,158
	o-Nitrophenol	4,044	4,183
m-Nitrotoluene	*p*-Toluidine	3,365	4,012
	o-Nitrophenol	3,432	4,133
	Naphthalene	3,022	4,384

greatest difference in the heat of fusion calculations. The values calculated are of the same order of magnitude as the calculated values in the International Critical Tables. The value for naphthalene agrees closely with the calorimetrically-determined value in the Critical Tables. However, the values for o-nitrophenol and p-toluidine show about a six percent variation.

SUMMARY

The temperature-composition data have been determined for the systems: p-nitrotoluene with p-toluidine and o-nitrophenol, and m-nitrotoluene with p-toluidine, o-nitrophenol and naphthalene.

The data show that these pairs form simple systems without compound formation. The systems are closely ideal in nature.

The latent heats of fusion have been calculated from the $\log_{10} X - 1/T$ curves.

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ERRATA

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Frontispiece (in color): Fig. "2" should be "3" and fig. "3" should be "2".

VOLUME 48, NO. 1

Page 85, lines 32 and 33: "To test the absorption of water applied in drops, they sprayed certain wilted plants," should read, "To test the absorption of water applied in drops, Ganong sprayed certain wilted plants," etc.

Line 37: "they allowed young *Helianthus* plants," should read, "he allowed young *Helianthus* plants," etc.